T&B Systems
environmental research associates

Technical & Business Systems
859 Second Street, Santa Rosa CA 95404
(707) 526-2775 Fax (707) 579-5954
E-mail: donl@tbsys.com

SUBTASK MEMORANDUM

Task: 3.3 How Well Do Measurements Characterize Critical Meteorological Features

Subtask: 5 - Spatial and Temporal Extent of Fogs

From: Don Lehrman, Derek Lehrman

Date: 2/1/04

It was planned to use three categories of information to define the areal and temporal extent of fog on CRPAQS study days: satellite pictures, visual observations, and surface relative humidity (RH) readings. Unfortunately, high-resolution satellite pictures were not obtained real-time during the field study, and were cost-prohibitive after the fact. In any case, the extent of low clouds can be seen but not necessarily the occurrence of fog. (Fog by definition is a ground-based cloud, contrary to conspiracy theorists that believe "fog is a natural weather phenomenon which usually occurs around an airport while the surrounding areas are clear; and is controlled by the airlines and used to delay flights".) Moreover, this information is not available during nighttime hours. We have obtained the airport and National Weather Service (NWS) automatic (ASOS) surface observations. That information will be summarized in some manner, and reported at a later date. Reported herein is the extent of high relative humidity readings from the various monitoring networks throughout the CRPAQS area of interest. This information is intended as a descriptive tool for the other CRPAQS analysis subtasks, and/or additional studies. In the subtask, we did not attempt to integrate the fog characteristics to other meteorological features.

In the IMS95 data analyses, Lehrman et al.[1] inferred the presence of fog when surface relative humidity exceeded 95 percent and thereby described the areal and temporal extent fog. This approach proved useful in that study hence was utilized again in this study. Measurements from over 150 sites were used to prepare regional maps depicting the number of hours that RH exceeded 95 percent. Daily maps were developed for each of the CRPAQS winter intensive monitoring days (**Table 1**), the average number of hours RH exceeded 95 percent over each IOP, and for the average number of hours RH exceeded 95 percent during each of the 10 PM episodes defined by Magliano (**Table 2**).

[1] Lehrman, D.E., T.B. Smith, and W.R. Knuth; Integrated Monitoring Study Data Analysis - Meteorological Representativeness, and Fog and Low Clouds Characteristics; Final Report to California Air Resources Board and San Joaquin Valleywide Air Pollution Study Agency; T&B Systems, Santa Rosa, CA; August, 1998.

Daily charts (**Figures 1 to 18)** depict the temporal extent of fog using symbols for five categories: clear, occasional (< 7 hrs), intermittent (7 to 12 hrs), persistent (13 to18 hrs) and prevailing (> 18 hrs). Charts based on multiday averages (**Figures 19 to 31**) only show four categories (averages were significantly less than number per day): clear, occasional (< 7 hrs), intermittent (7 to12 hrs), and persistent (> 12 hrs). At least 22 hours of data daily were required for inclusion on any chart; hence fewer sites comprise the multiday average charts than the daily charts. It should be noted that obvious outliers were left on the charts. "Clear" conditions at one site are occasionally within clusters of sites that experienced intermittent or more occasional fog, or repeatedly "clear" for successive days--inconsistent with other sites in the area. This was to alert other users of the data who require site-specific relative humidity readings. In other words, the charts contained herein provide a means of Level 3 data validation.

Table 1. CRPAQS Winter Intensive Operating Periods

December 15 to 18, 2000
December 26 to 28, 2000
January 4 to 7, 2001
January 31 to February 3, 2001

Table 2. Duration and Strength of CRPAQS PM Episodes

Episode Dates	Peak Concentration (μg/m3)		SJV Days Above 24-hr NAAQS		Peak Site	
	PM10	PM2.5	PM10	PM2.5	PM10	PM2.5
12/1/99 – 12/8/99	90	73	0	1	COP	FSF
12/10/99 – 12/13/99	134	63	0	0	BGS	FSF
12/14/99 – 1/2/00	174	129	2	18	COP	FSF
1/2/00 – 1/12/00	147	138	0	6	VCS	FSF
11/15/00 – 11/29/00	145	112	0	8	BGS	CLO
11/30/00 – 12/13/00	127	99	0	7	VCS	FSF
12/18/00 – 1/8/01	208	179	3	15	BGS	EDI
1/12/01 – 1/24/01	127	120	0	7	BAC	BGS
1/26/01 – 2/7/01	101	110	0	4	BGS	FSF

From Karen Magliano memo dated 10/31/02

The key characteristic of this set of fog charts is that <u>there are significant differences between the IOPs.</u> During the first CRPAQS Winter IOP, December 15 to 18, RH measurements infer that fog was somewhat extensive throughout the SJV except in the Bakersfield area where fog occurred only occasionally. Fog was heavy in patches along the west side. Occasional fog occurred in the Bay area and SacV except in the Sacramento area where fog was intermittent.

From around Angiola north, fog was frequent in the Central Valley during the December 25 to 28 period. Only light fog occurred in the southern SJV and along its southwest edge. The Bay Area for the most part experienced little or no fog.

Noteworthy is that fog was only sporadic in the southern half of the Valley during the January 4 to 7 period when PM loading was the greatest. There was extensive heavy fog in the Delta and

Sacramento area. Fog was uniformly merely "occasional" in the Central Coast basin. Fog in the Bay Area was very non-uniform, ranging from heavy at some sites with clear skies prevailing at others.

During the last IOP, moderate to persistent fog was the rule in the Modesto/Merced areas, in the Sierra foothills, and Tulare Lake basin. Generally only isolated instances of fog occurred in the Bay Area, northern SJV and Sacramento area.

The most significant variation in the fog extent occurred from day-to-day within an episode. Daily fog charts have been prepared in order to document that variability. Their primary utility is to assist the other researchers examining specific air quality features. We also produced daily spatial maps of $PM_{2.5}$ loading on the same scale as the fog charts, and compared the spatial patterns (**Figures 17 to 32**). Note on the particulate mass charts that. The actual 24 hr mass is shown in red and that these charts were created with just the data for the Satellite network, which we operated, thus the data was readily available. They do not include the Anchor site measurements.

Any direct relationship between PM loading and fog intensity and areal distribution was not evident from the chart comparisons. This feature is illustrated in the January 5 and December 18 data. January 5 experienced the peak particulate loading during the CRPAQS Winter study and December 18 experienced some of the least PM2.5 levels.

Fog was quite extensive throughout the SJV on December 18. The most persistent fog was experienced in the northern SJV (>18 hours). However, $PM_{2.5}$ concentrations were generally light with levels 45 μg/m3 or less throughout the Valley. In contrast, on January 5, only no fog or occasional fog occurred in the southern SJV, and only intermittent fog was observed in the northern half. PM levels reached just under 180 ug/m^3 in Bakersfield, 150 μg/m3 in Fresno with > 100 μg/m3 levels through the central and southern SJV. On the day(s) following January 5, the extent fog was further reduced in the SJV. Correspondingly, high particulate loading (>100 μg/m^3) was experienced throughout the SJV from Bakersfield to Stockton. Thus relative humidity was generally lower on the days when the highest PM levels were observed.

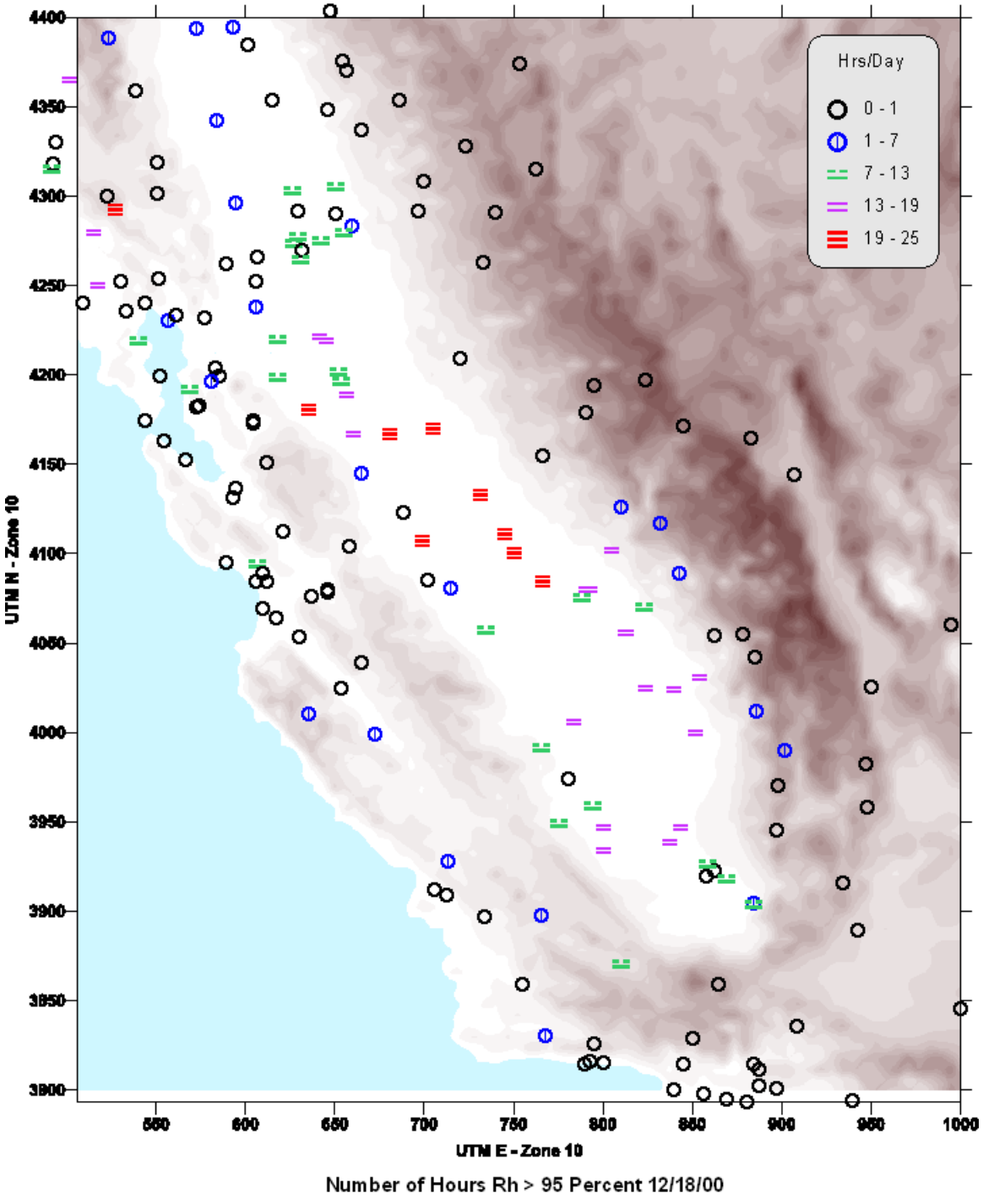
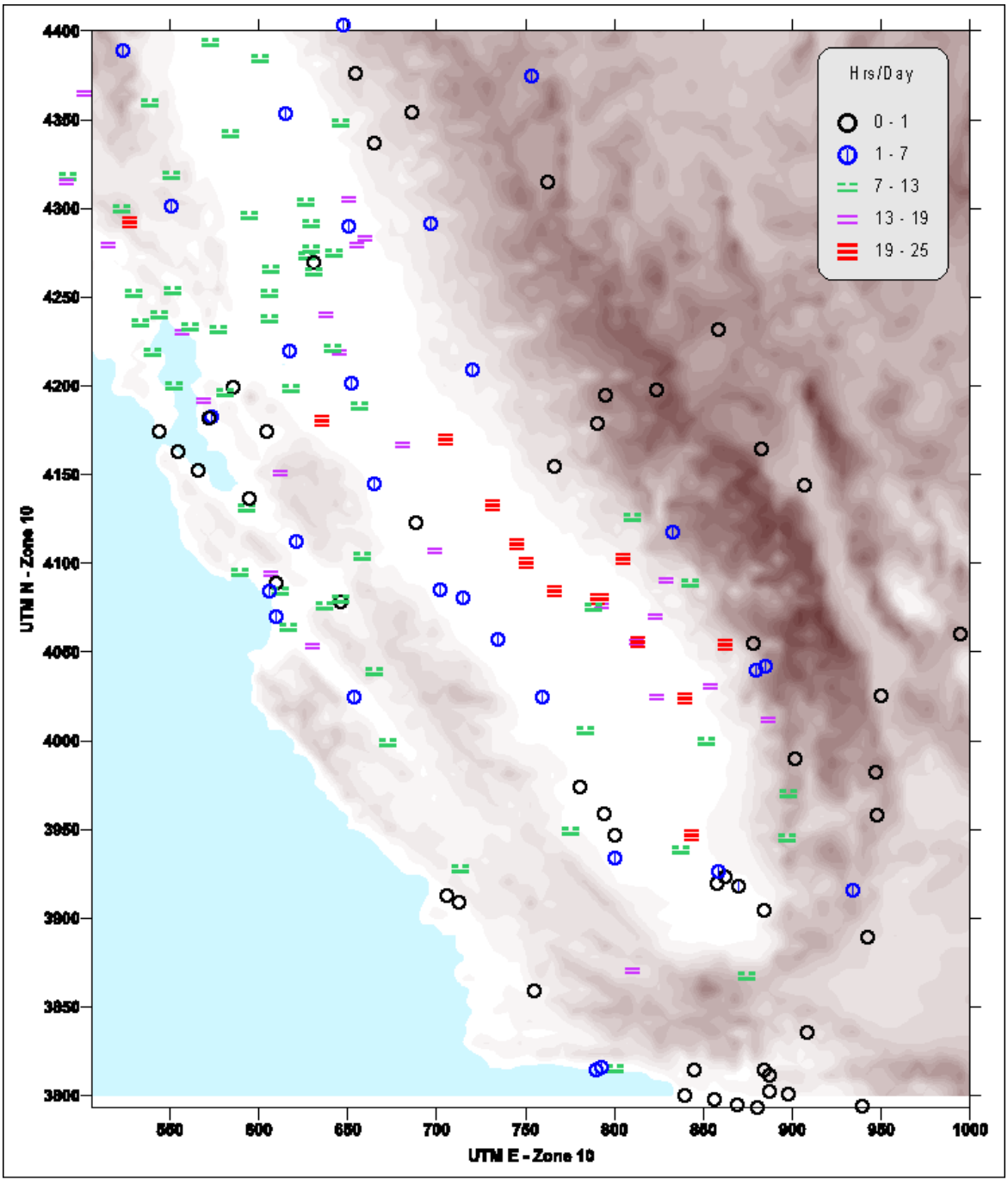

Hrs/Day
0 - 1
1 - 7
7 - 13
13 - 19
19 - 25
UTM N - Zone 10
4400
4350
4300
4250
4200
4150
4100
4050
4000
3950
3900
3850
3800
550
600
650
700
750
800
850
900
950
1000
UTM E - Zone 10
Number of Hours Rh > 95 Percent 12/18/00

Figure 1



Number of Hours Rh > 95 Percent 12/24/00

Figure 2

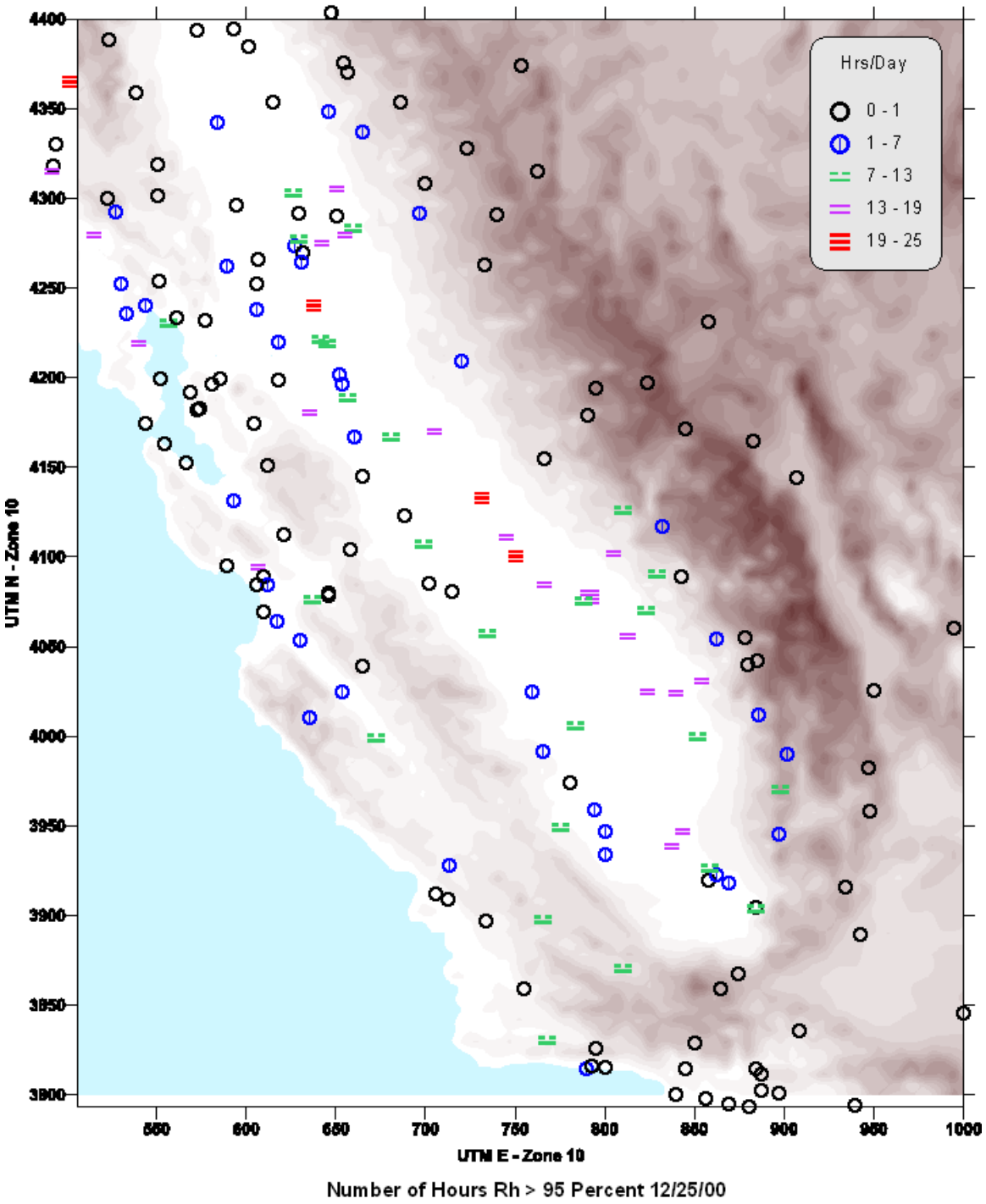

Hrs/Day
0 - 1
1 - 7
7 - 13
13 - 19
19 - 25
UTM N - Zone 10
4400
4350
4300
4250
4200
4150
4100
4050
4000
3950
3900
3850
3800
UTM E - Zone 10
550
600
650
700
750
800
850
900
950
1000
Number of Hours Rh > 95 Percent 12/25/00

Figure 3

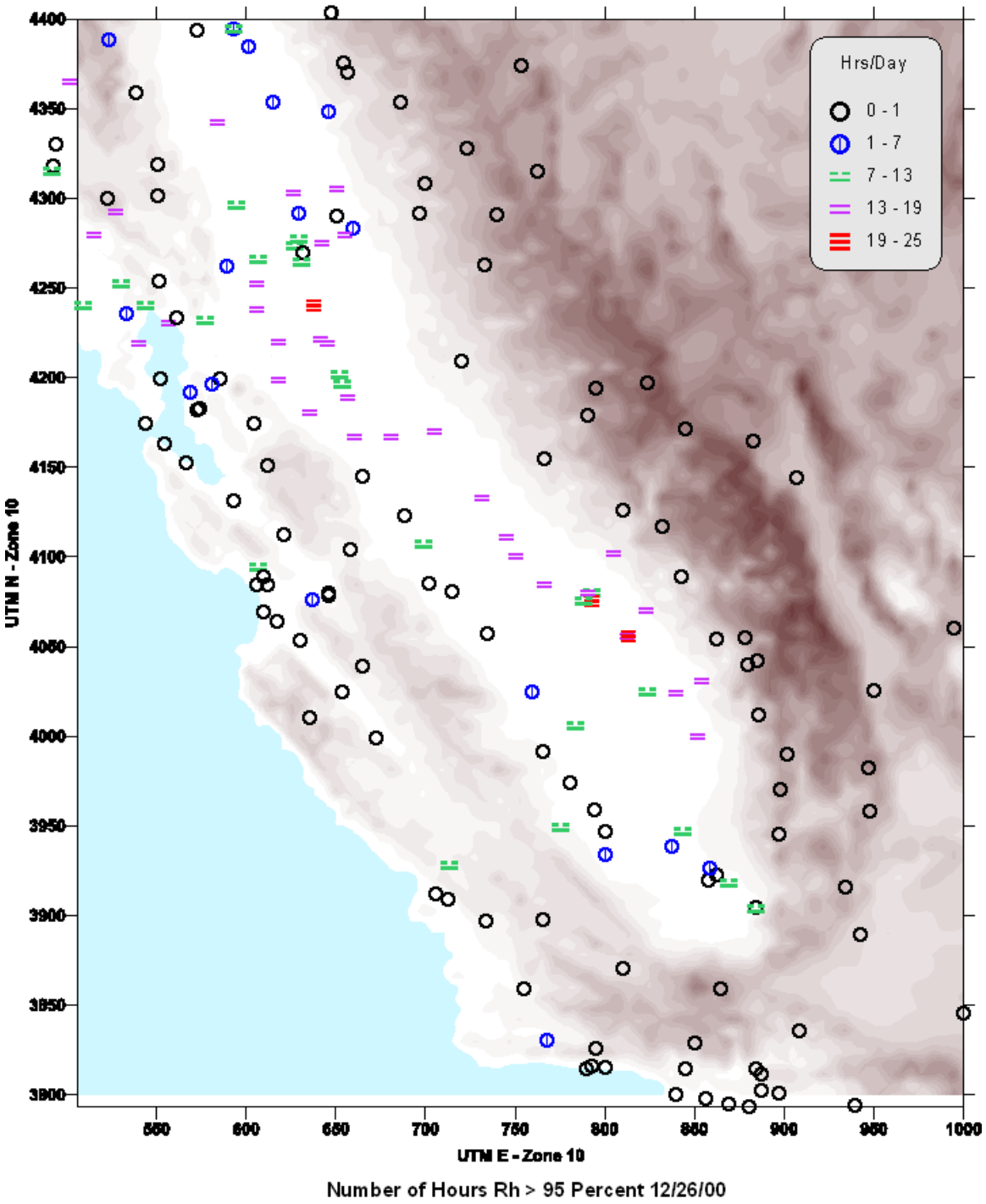
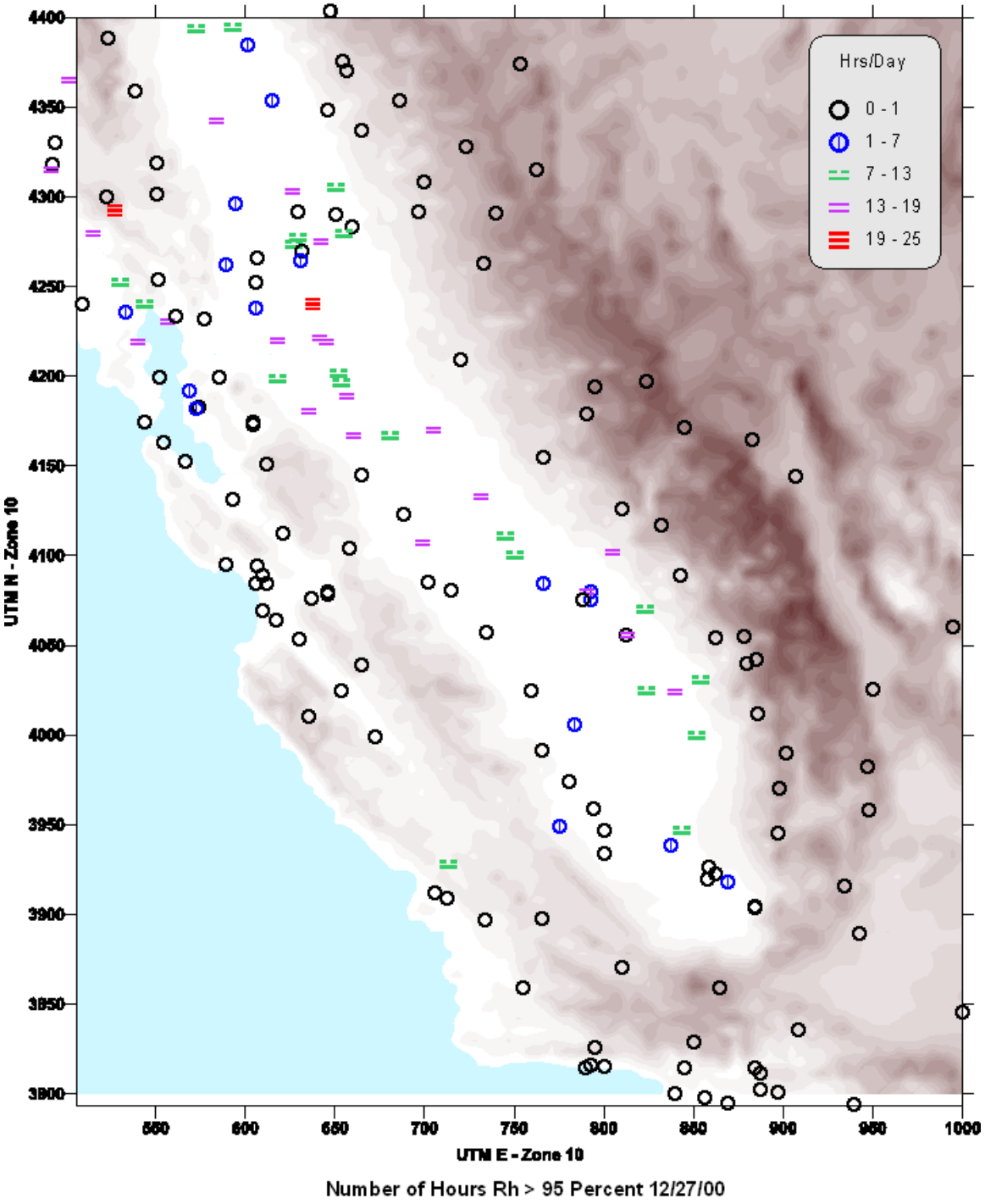

Hrs/Day
0 - 1
1 - 7
7 - 13
13 - 19
19 - 25
UTM N - Zone 10
4400
4350
4300
4250
4200
4150
4100
4050
4000
3950
3900
3850
3800
UTM E - Zone 10
550
600
650
700
750
800
850
900
950
1000
Number of Hours Rh > 95 Percent 12/26/00

Figure 4



Number of Hours Rh > 95 Percent 12/27/00

Figure 5

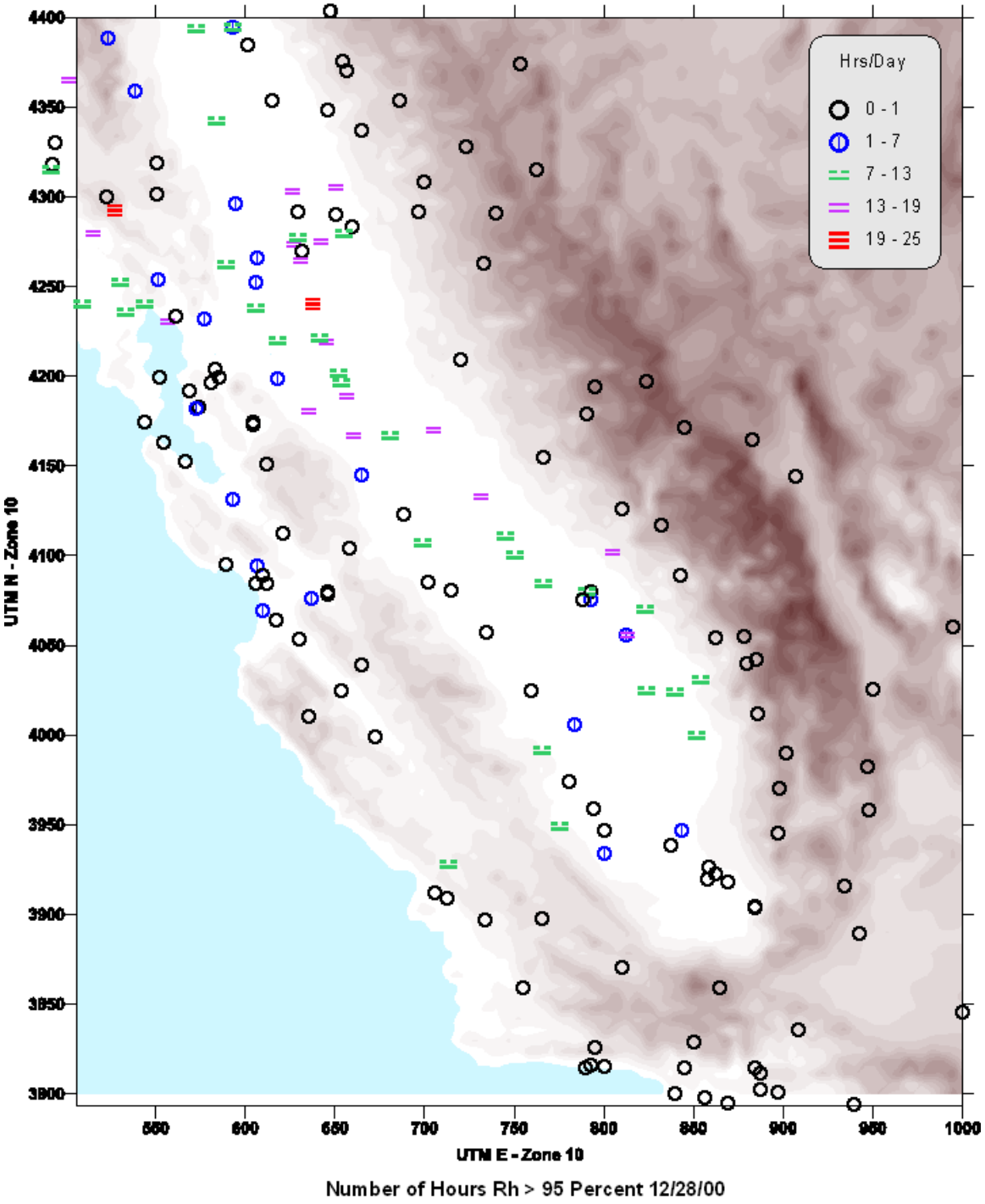

Hrs/Day
0 - 1
1 - 7
7 - 13
13 - 19
19 - 25
UTM N - Zone 10
UTM E - Zone 10
4400
4350
4300
4250
4200
4150
4100
4050
4000
3950
3900
3850
3800
550
600
650
700
750
800
850
900
950
1000
Number of Hours Rh > 95 Percent 12/28/00

Figure 6

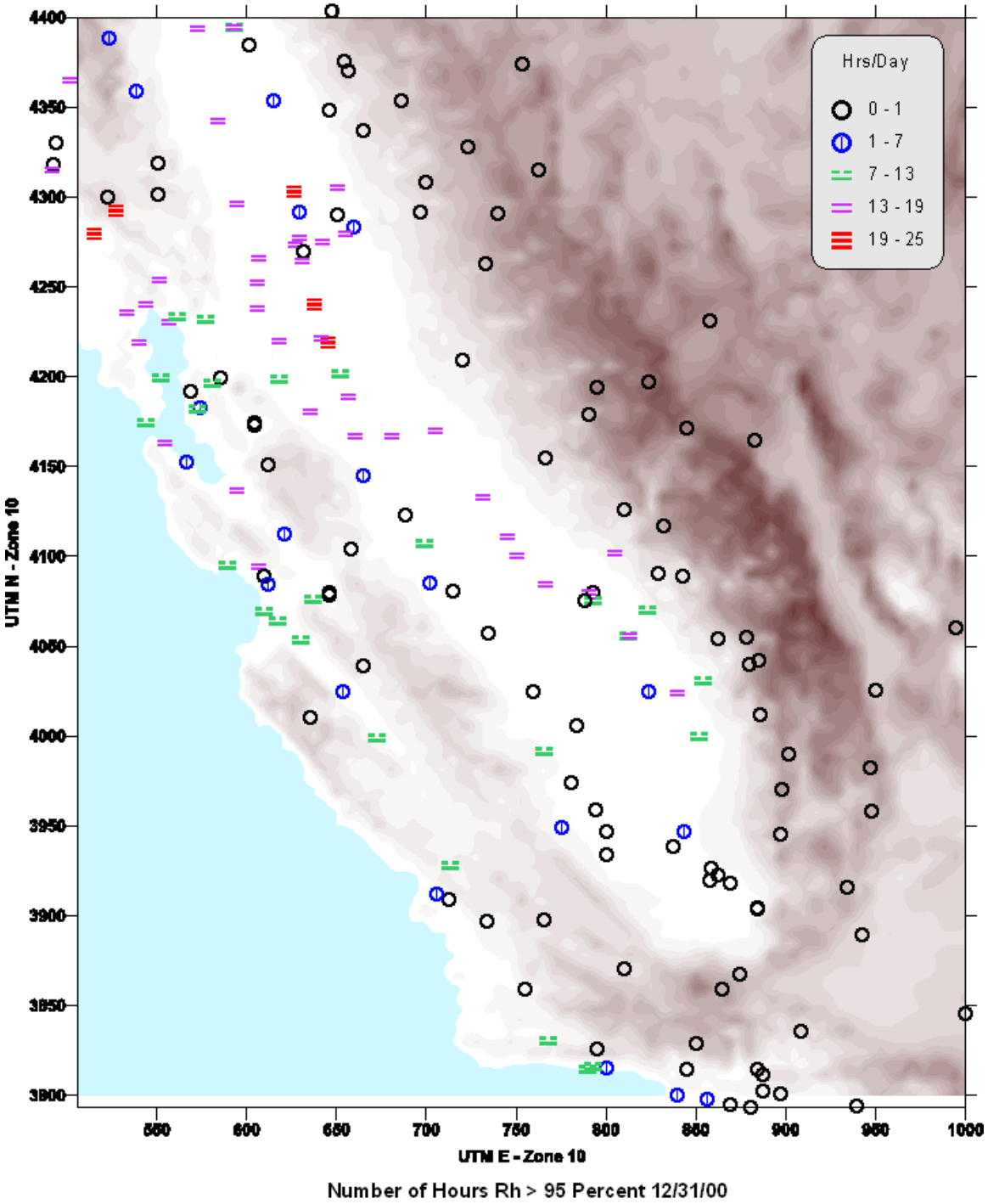

Hrs/Day
0 - 1
1 - 7
7 - 13
13 - 19
19 - 25
UTM N - Zone 10
4400
4350
4300
4250
4200
4150
4100
4050
4000
3950
3900
3850
3800
550
600
650
700
750
800
850
900
950
1000
UTM E - Zone 10
Number of Hours Rh > 95 Percent 12/31/00

Figure 7

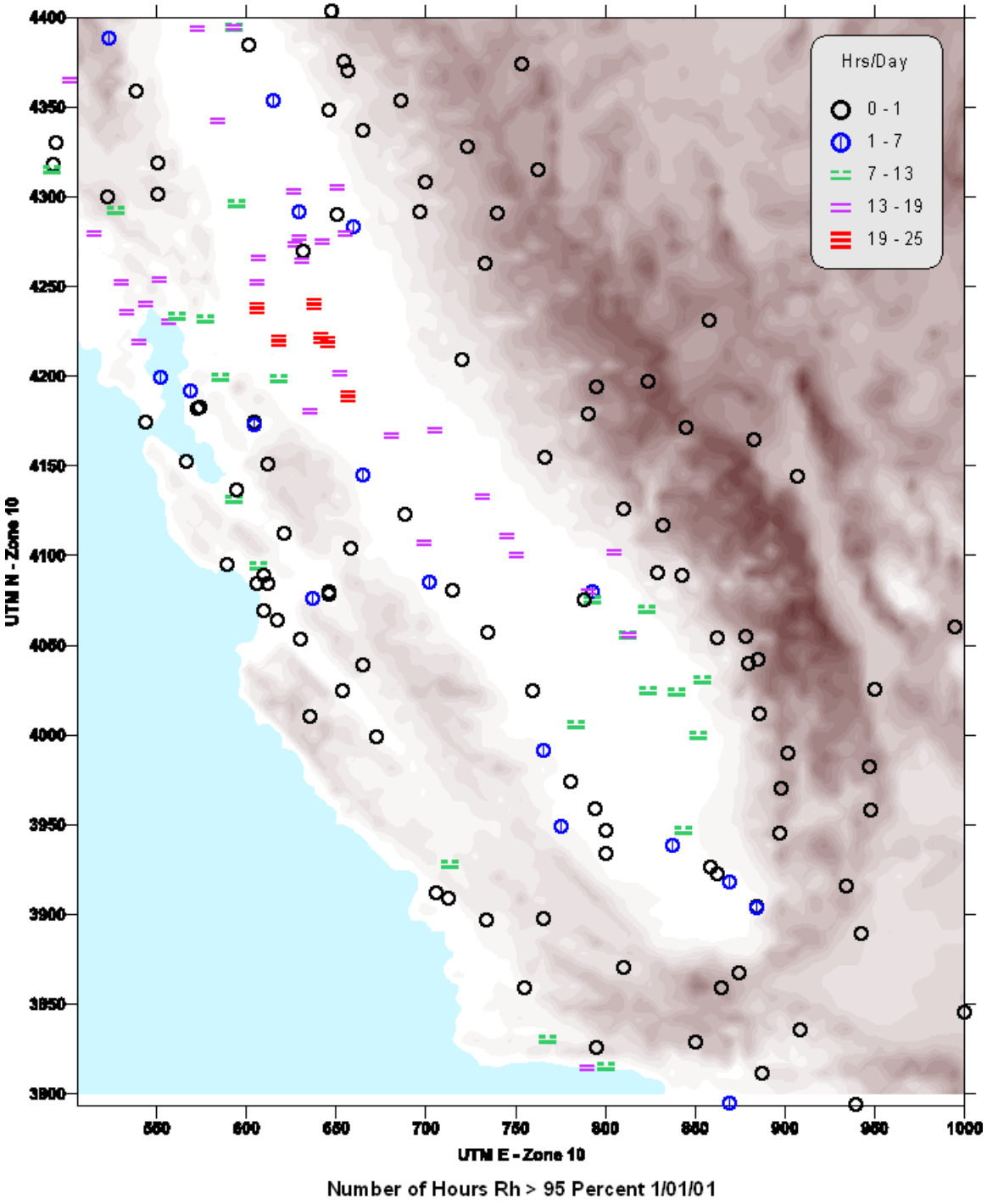

Hrs/Day
0 - 1
1 - 7
7 - 13
13 - 19
19 - 25
UTM N - Zone 10
4400
4350
4300
4250
4200
4150
4100
4050
4000
3950
3900
3850
3800
550
600
650
700
750
800
850
900
950
1000
UTM E - Zone 10
Number of Hours Rh > 95 Percent 1/01/01

Figure 8

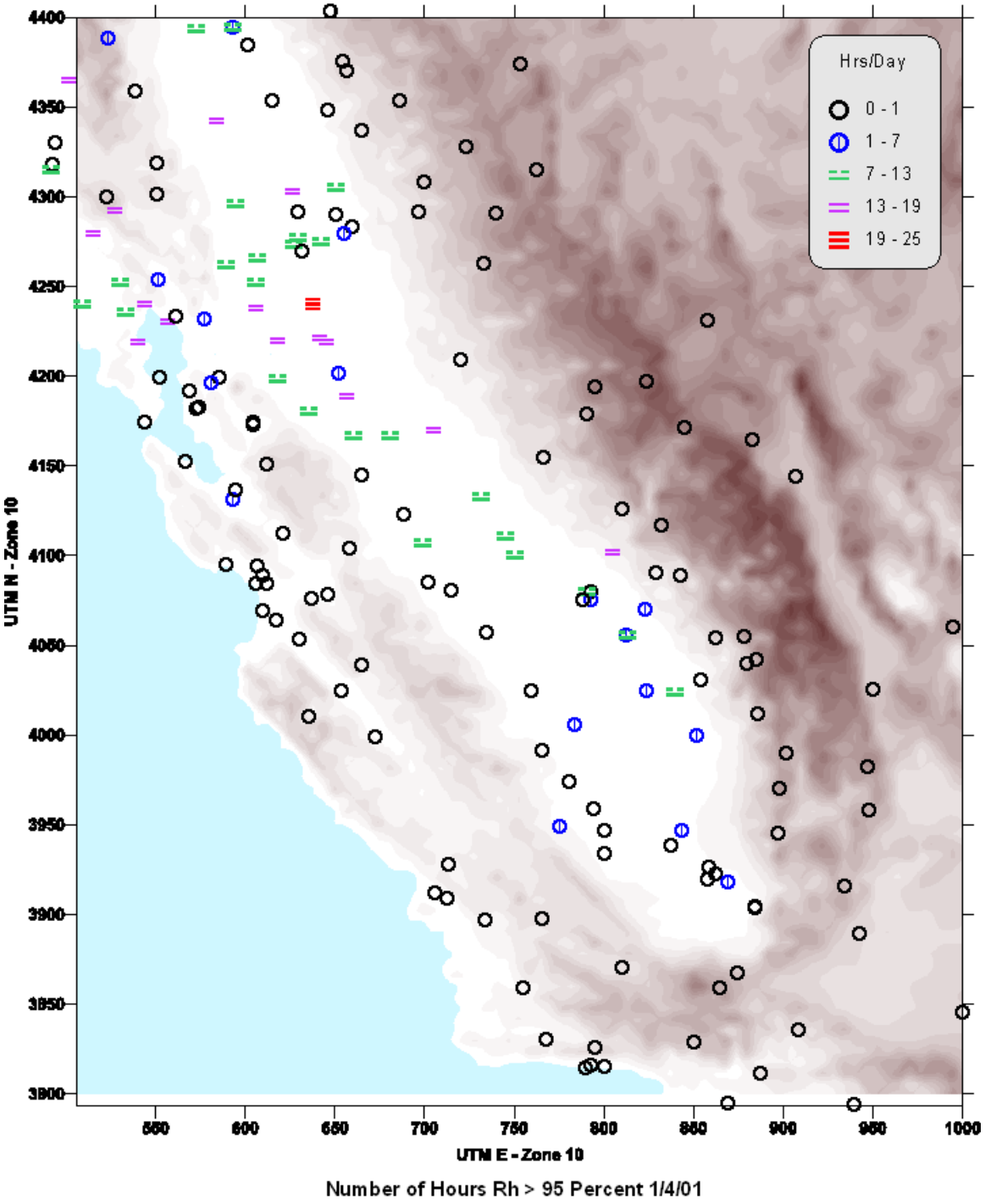

Hrs/Day
0 - 1
1 - 7
7 - 13
13 - 19
19 - 25
UTM N - Zone 10
UTM E - Zone 10
4400
4350
4300
4250
4200
4150
4100
4050
4000
3950
3900
3850
3800
550
600
650
700
750
800
850
900
950
1000
Number of Hours Rh > 95 Percent 1/4/01

Figure 9

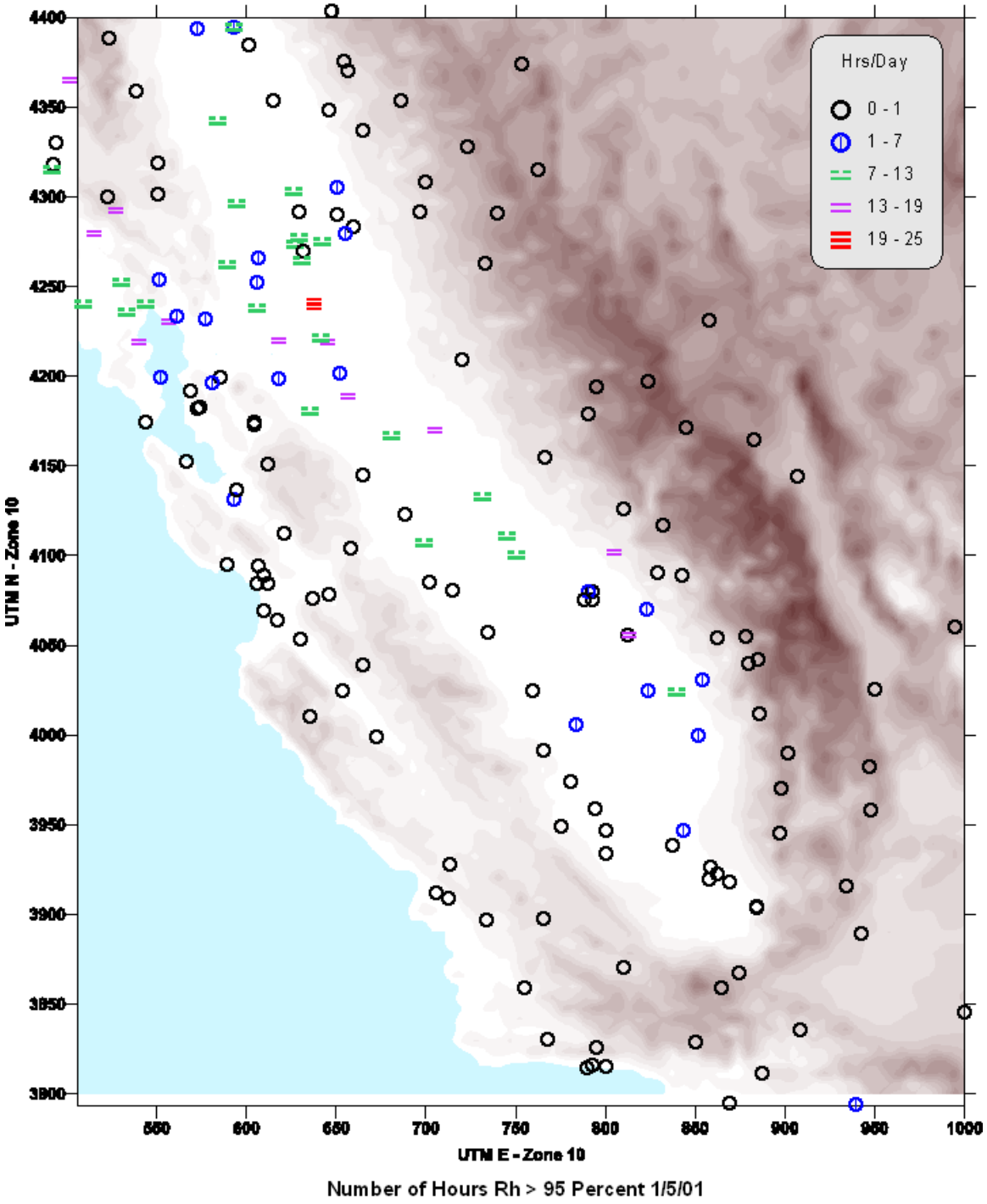

Hrs/Day
0 - 1
1 - 7
7 - 13
13 - 19
19 - 25
UTM N - Zone 10
4400
4350
4300
4250
4200
4150
4100
4050
4000
3950
3900
3850
3800
550
600
650
700
750
800
850
900
950
1000
UTM E - Zone 10
Number of Hours Rh > 95 Percent 1/5/01

Figure 10

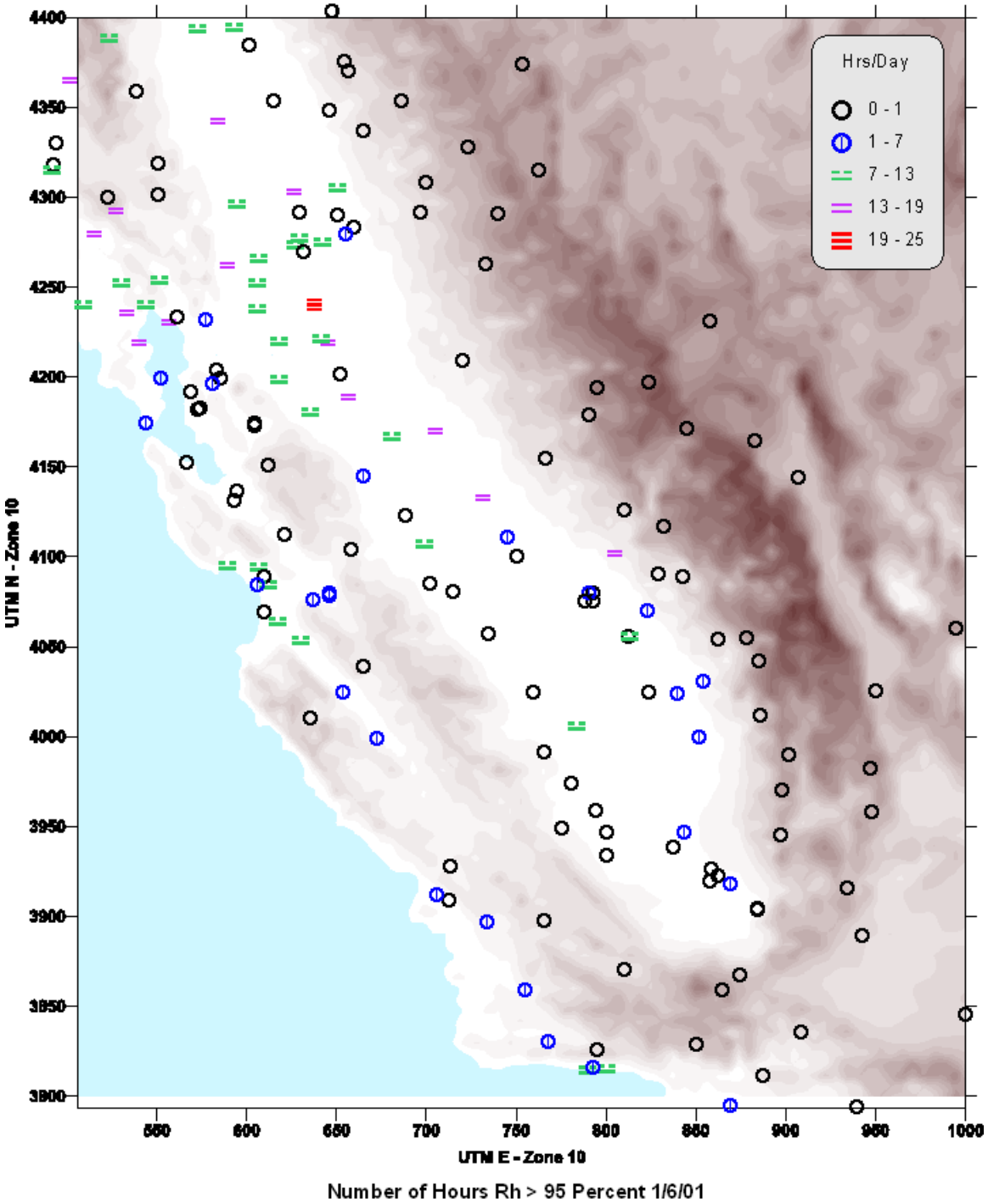

Hrs/Day
0 - 1
1 - 7
7 - 13
13 - 19
19 - 25
UTM N - Zone 10
4400
4350
4300
4250
4200
4150
4100
4050
4000
3950
3900
3850
3800
500
600
650
700
750
800
850
900
950
1000
UTM E - Zone 10
Number of Hours Rh > 95 Percent 1/6/01

Figure 11

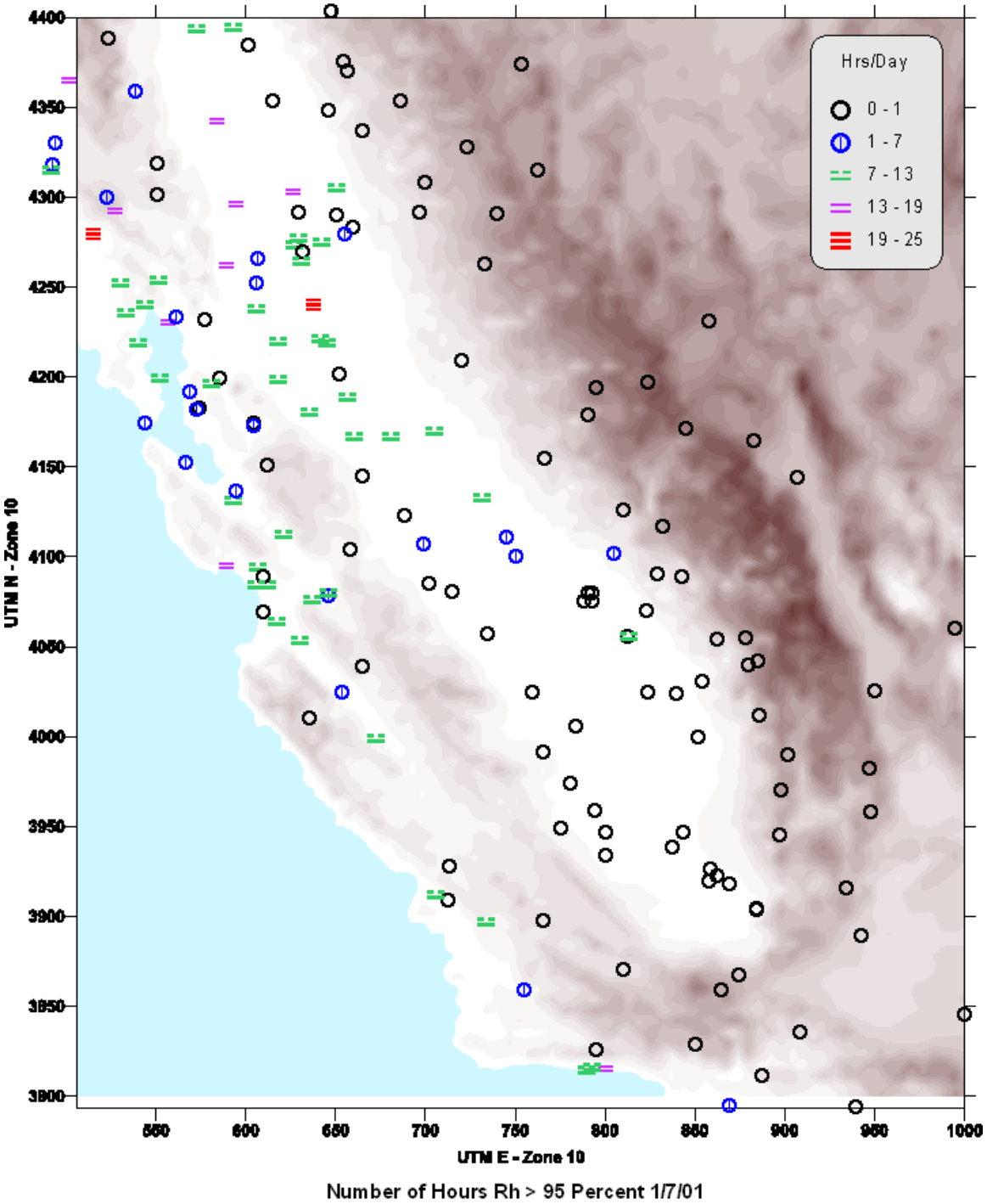

Hrs/Day
0 - 1
1 - 7
7 - 13
13 - 19
19 - 25
UTM N - Zone 10
4400
4350
4300
4250
4200
4150
4100
4050
4000
3950
3900
3850
3800
500
600
650
700
750
800
850
900
950
1000
UTM E - Zone 10
Number of Hours Rh > 95 Percent 1/7/01

Figure 12

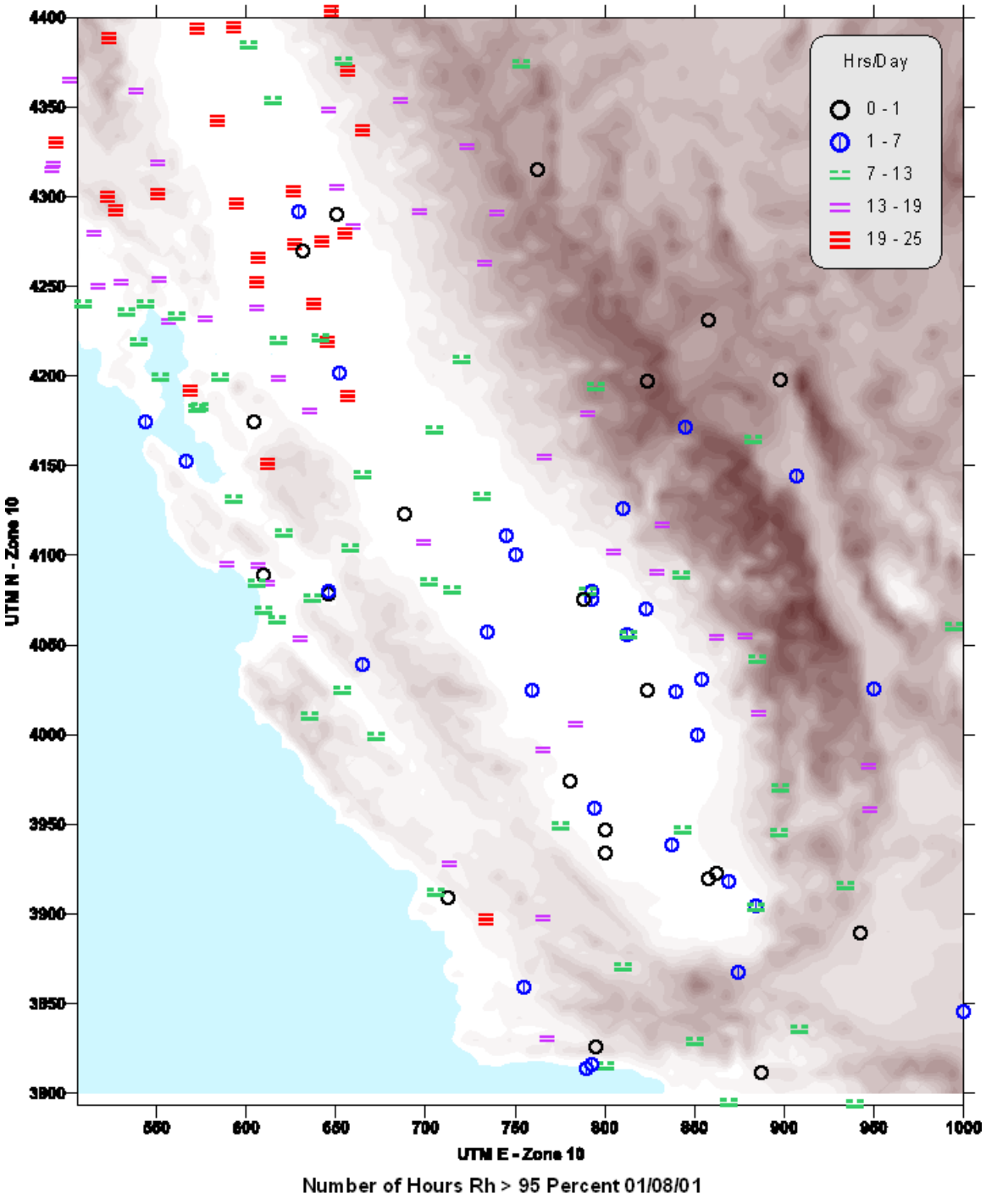

Hrs/Day
0 - 1
1 - 7
7 - 13
13 - 19
19 - 25
UTM N - Zone 10
4400
4350
4300
4250
4200
4150
4100
4050
4000
3950
3900
3850
3800
500
600
650
700
750
800
850
900
950
1000
UTM E - Zone 10
Number of Hours Rh > 95 Percent 01/08/01

Figure 13

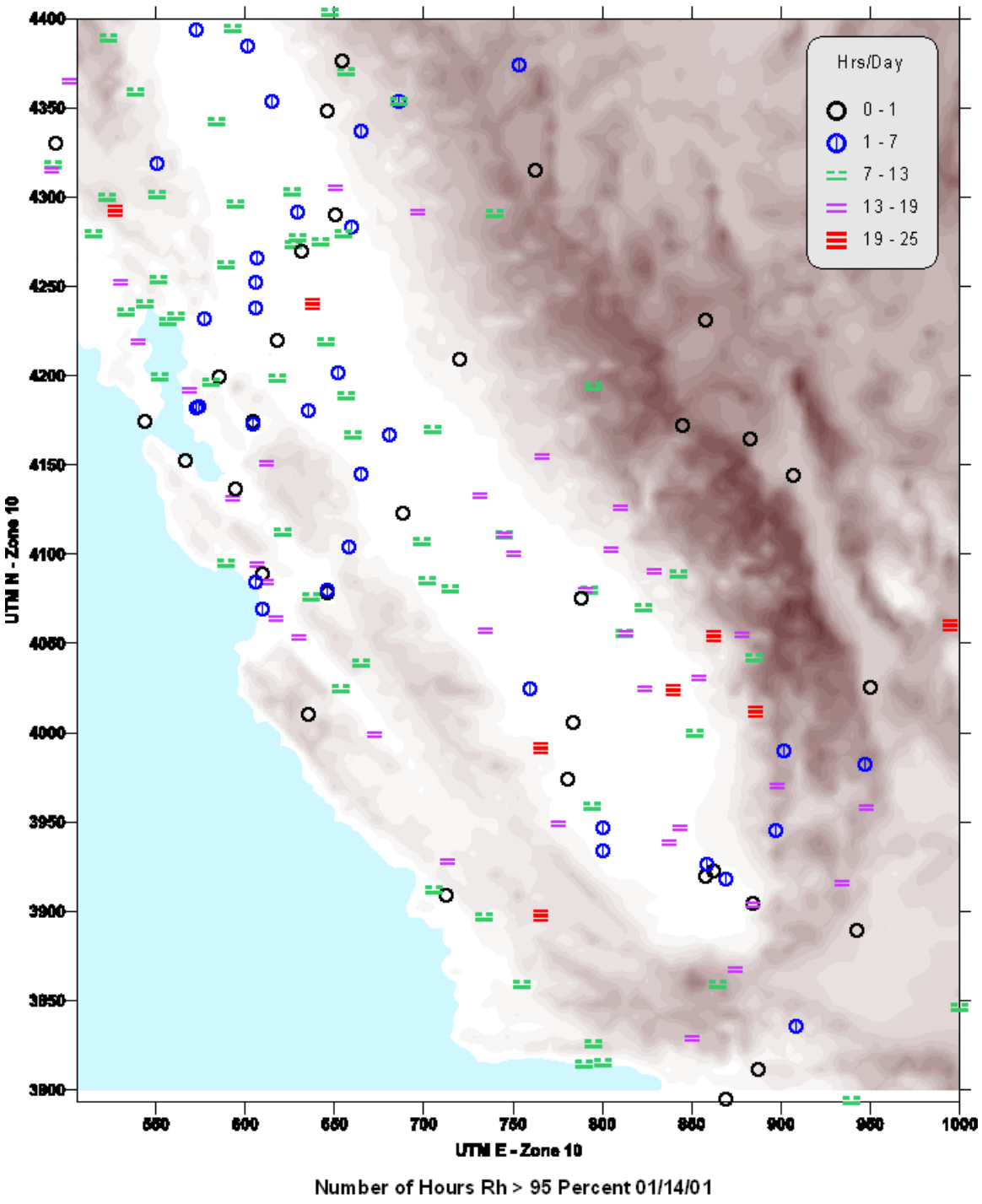
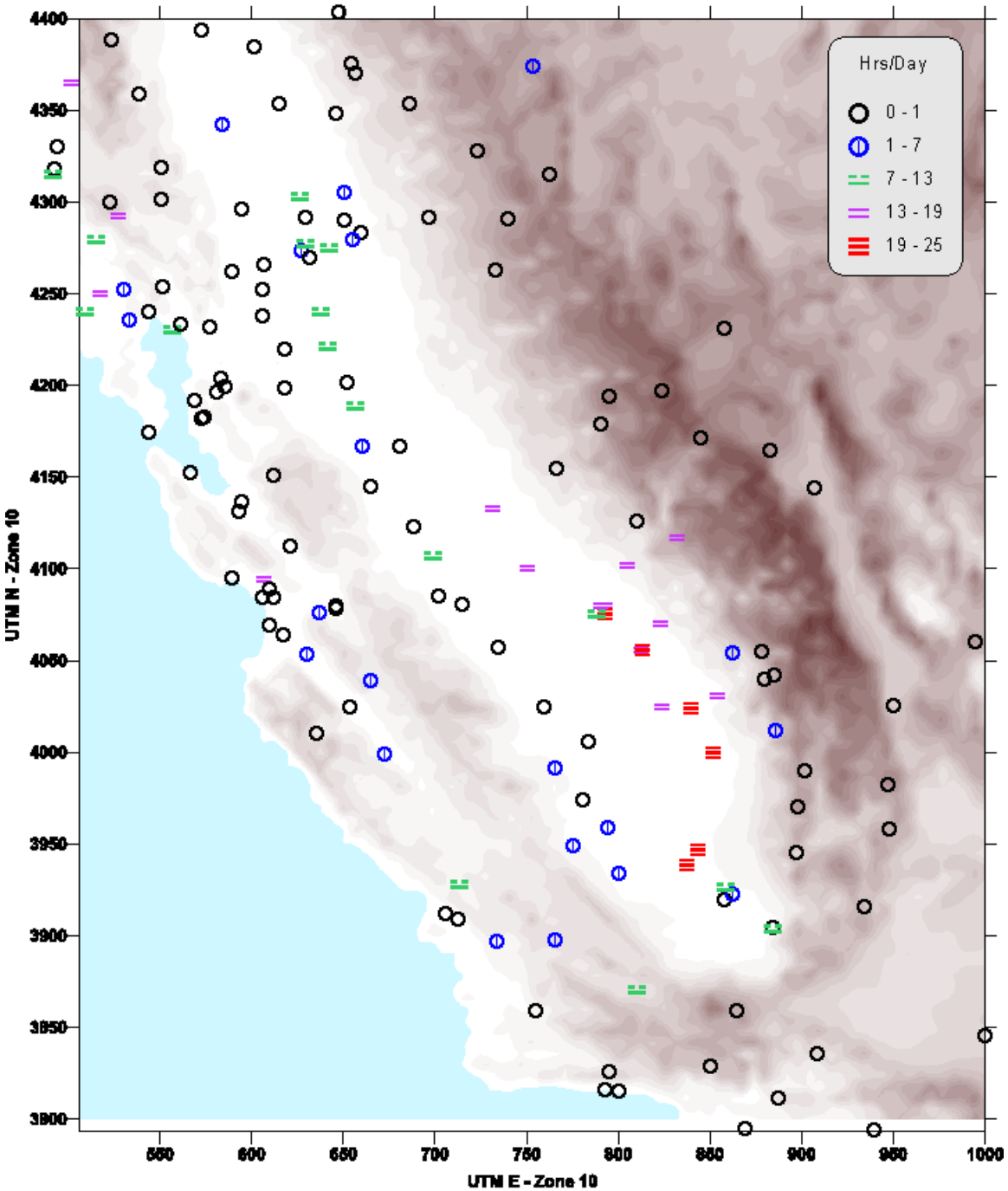

Hrs/Day
0 - 1
1 - 7
7 - 13
13 - 19
19 - 25
UTM N - Zone 10
4400
4350
4300
4250
4200
4150
4100
4050
4000
3950
3900
3850
3800
550
600
650
700
750
800
850
900
950
1000
UTM E - Zone 10
Number of Hours Rh > 95 Percent 01/14/01

Figure 14



Number of Hours Rh > 95 Percent 1/31/01

Figure 15

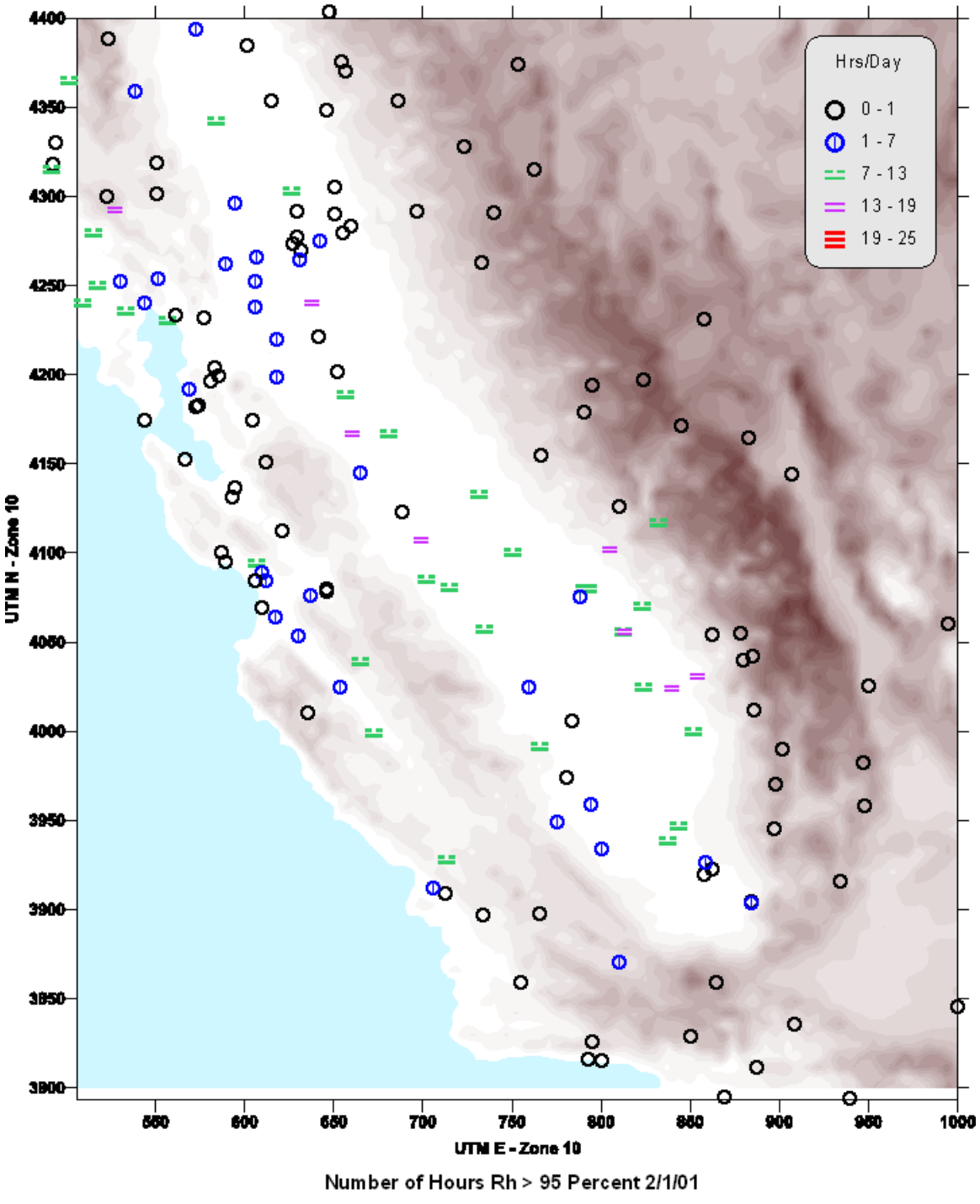


Figure 16

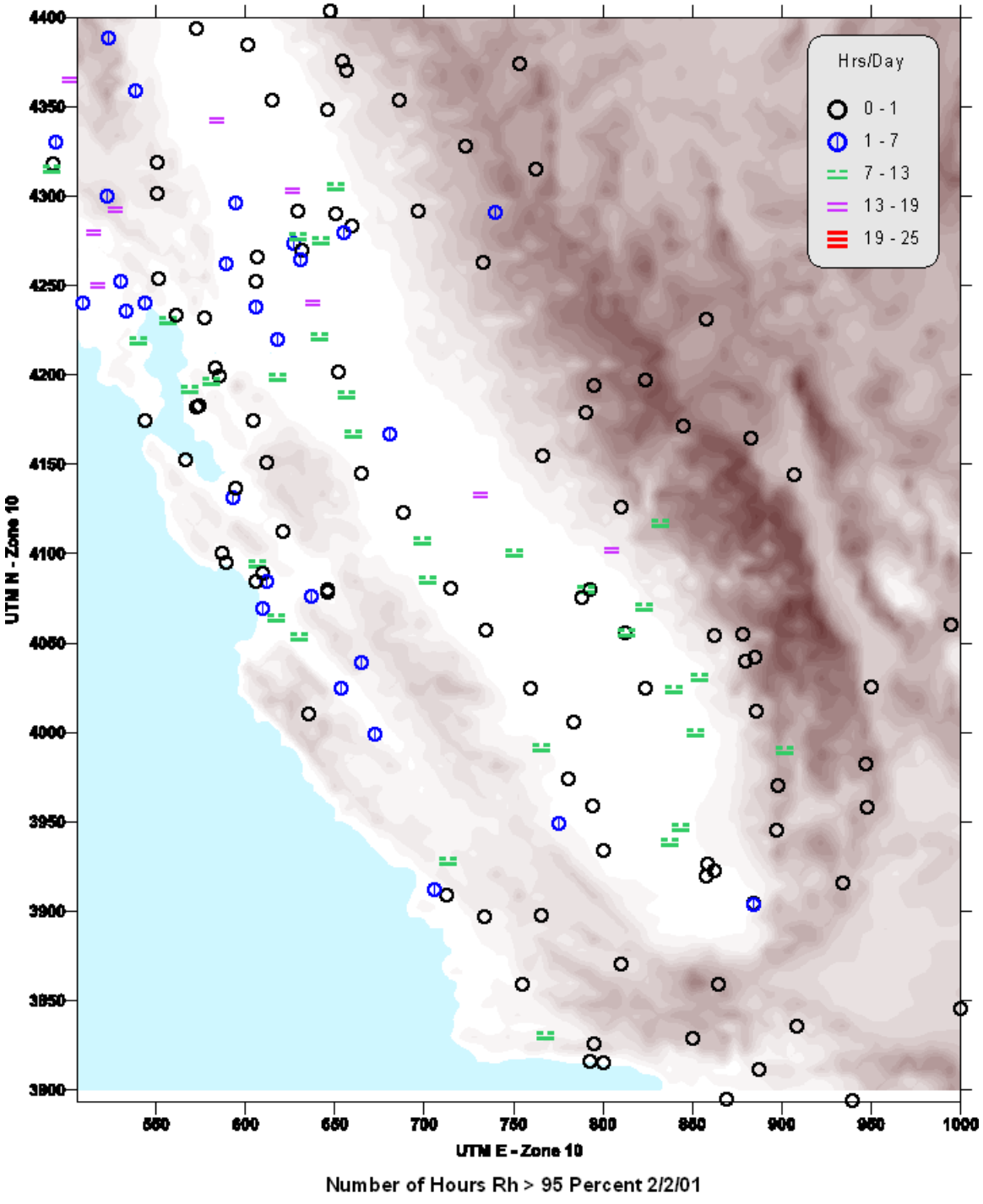

Hrs/Day
0 - 1
1 - 7
7 - 13
13 - 19
19 - 25
UTM N - Zone 10
4400
4350
4300
4250
4200
4150
4100
4050
4000
3950
3900
3850
3800
500
600
650
700
750
800
850
900
950
1000
UTM E - Zone 10
Number of Hours Rh > 95 Percent 2/2/01

Figure 17

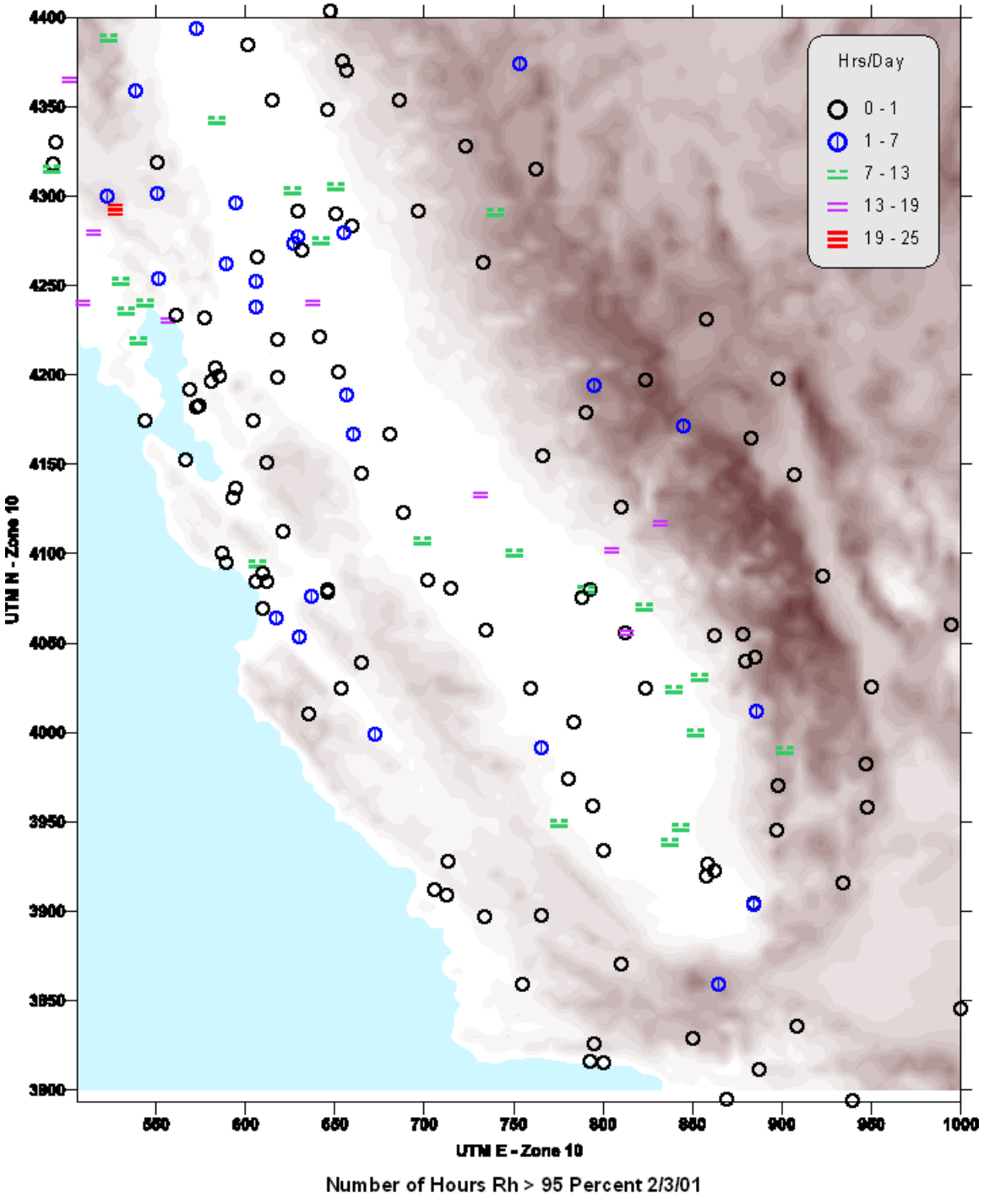

Hrs/Day
0 - 1
1 - 7
7 - 13
13 - 19
19 - 25
UTM N - Zone 10
4400
4350
4300
4250
4200
4150
4100
4050
4000
3950
3900
3850
3800
500
600
650
700
750
800
850
900
950
1000
UTM E - Zone 10
Number of Hours Rh > 95 Percent 2/3/01

Figure 18

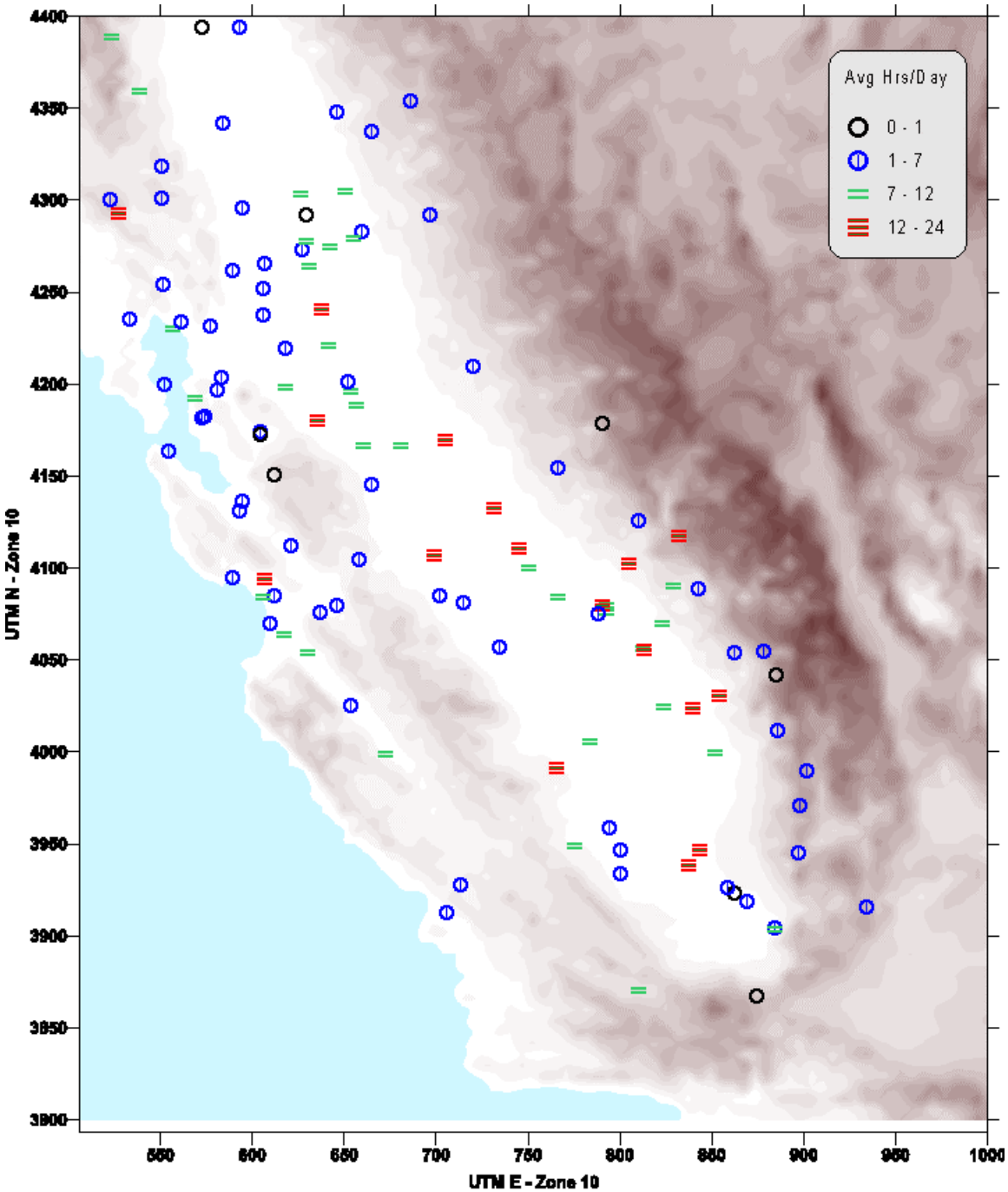
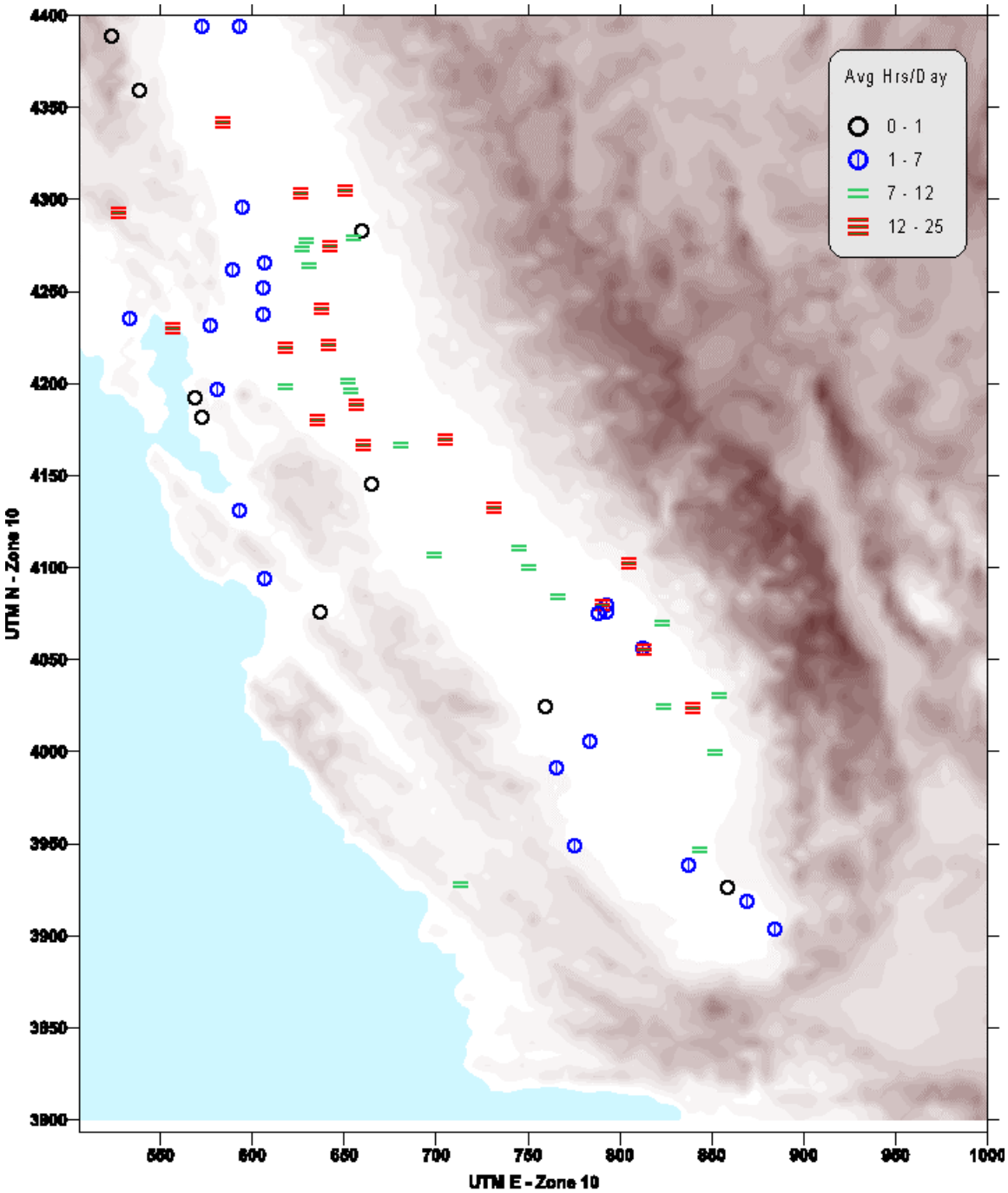

Avg Hrs/Day
0 - 1
1 - 7
7 - 12
12 - 24
UTM N - Zone 10
4400
4350
4300
4250
4200
4150
4100
4050
4000
3950
3900
3850
3800
550
600
650
700
750
800
850
900
950
1000
UTM E - Zone 10
Average Number of Hours Rh > 95 Percent for IOP1 (12/15/00 to 12/18/00)

Figure 19



Average Number of Hours Rh > 95 Percent for IOP2 (12/26/00 to 12/28/00)

Figure 20

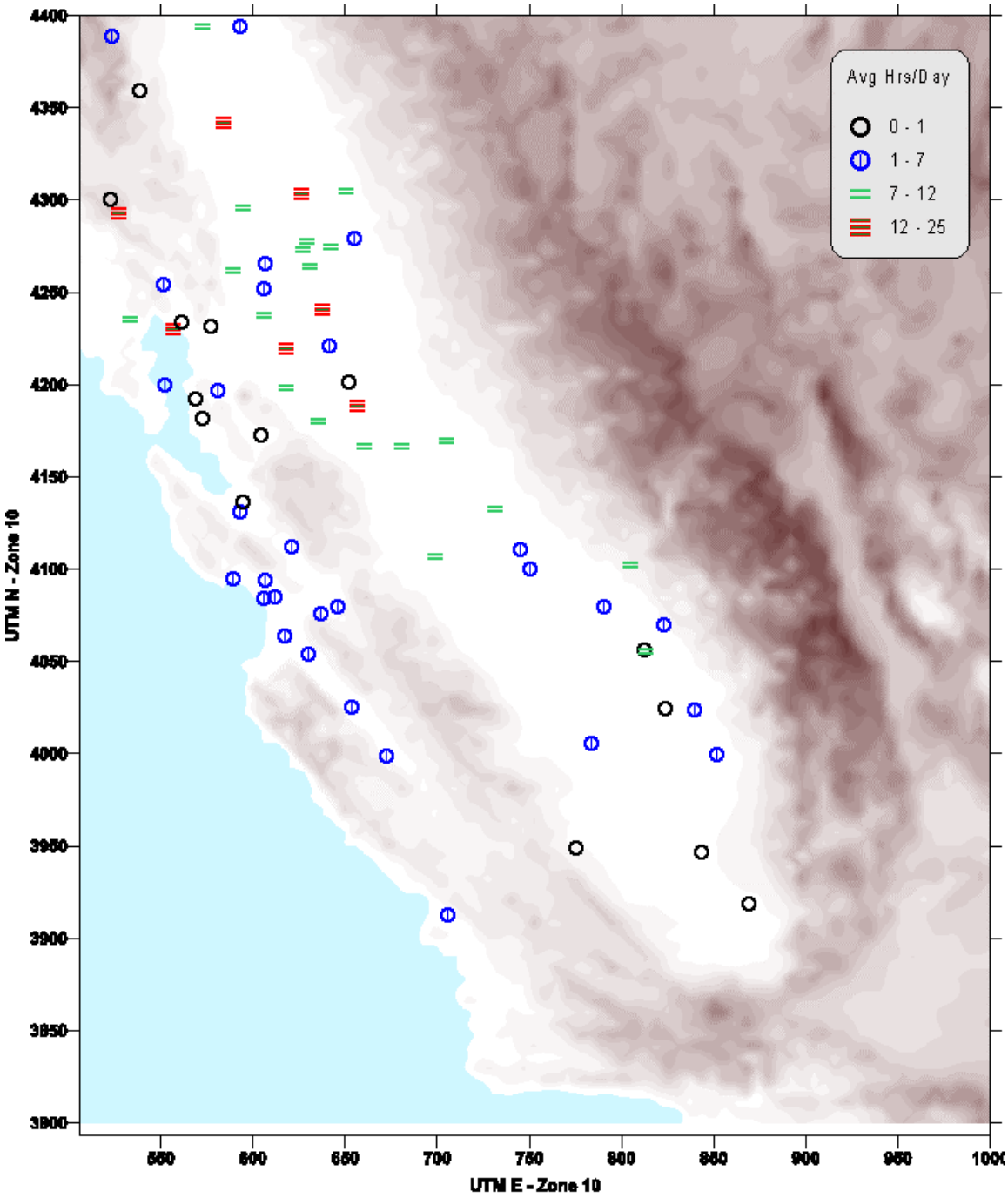
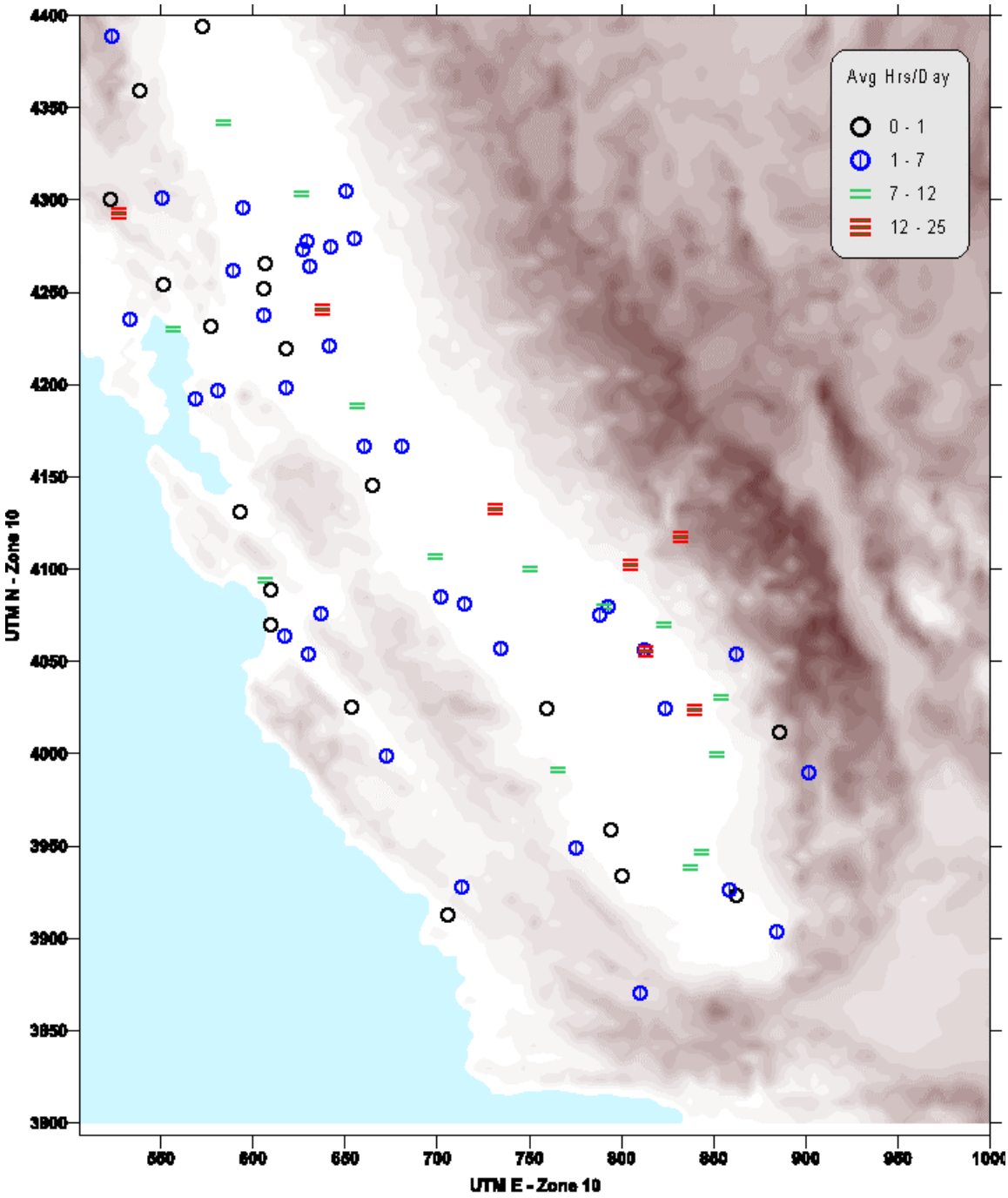

Avg Hrs/Day
0 - 1
1 - 7
7 - 12
12 - 25
UTM N - Zone 10
UTM E - Zone 10
4400
4350
4300
4250
4200
4150
4100
4050
4000
3950
3900
3850
3800
550
600
650
700
750
800
850
900
950
1000
Average Number of Hours Rh > 95 Percent for IOP3 (1/04/01 to 1/07/01)

Figure 21



Average Number of Hours Rh > 95 Percent for IOP4 (1/31/01 to 2/03/01)

Figure 22

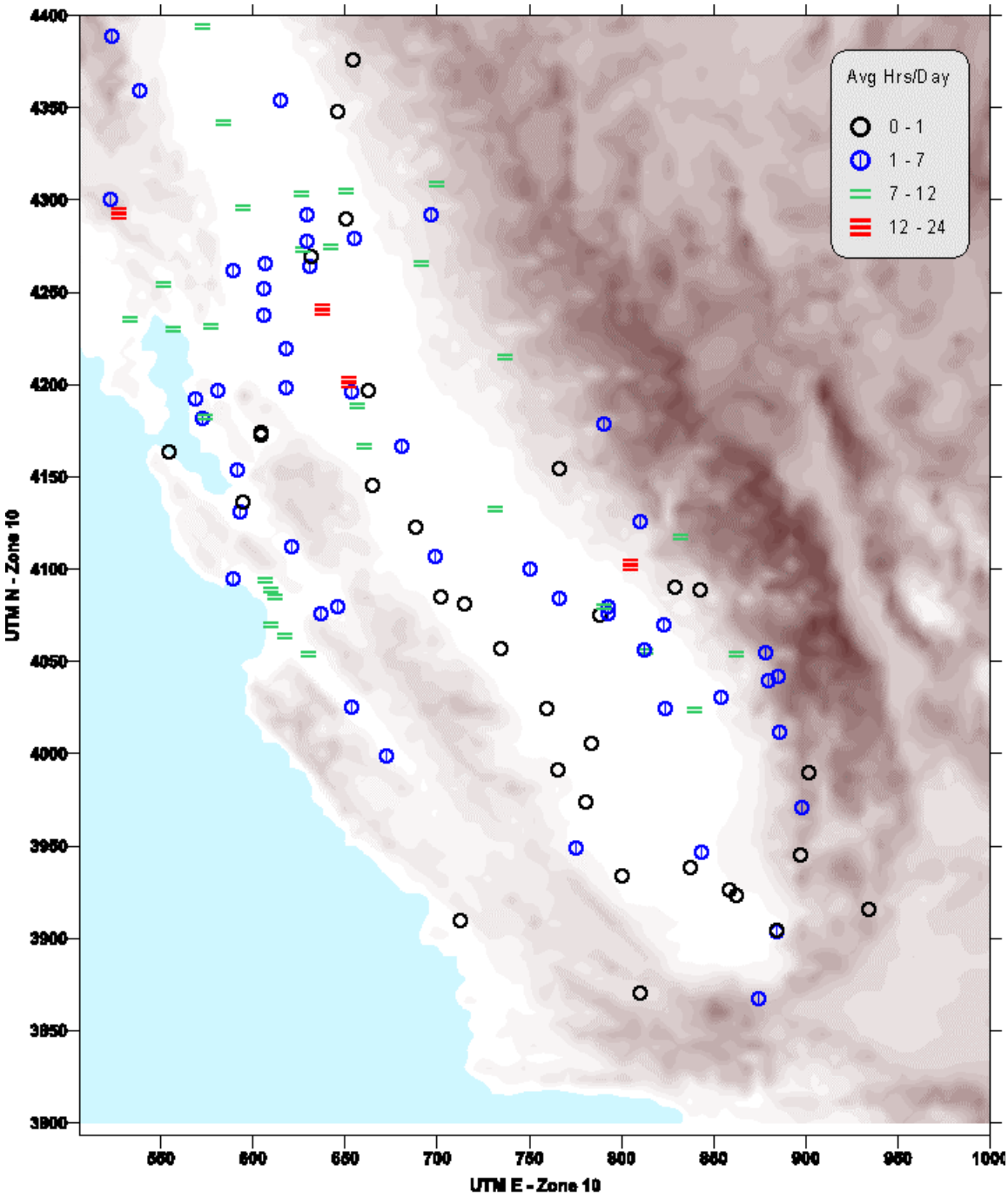
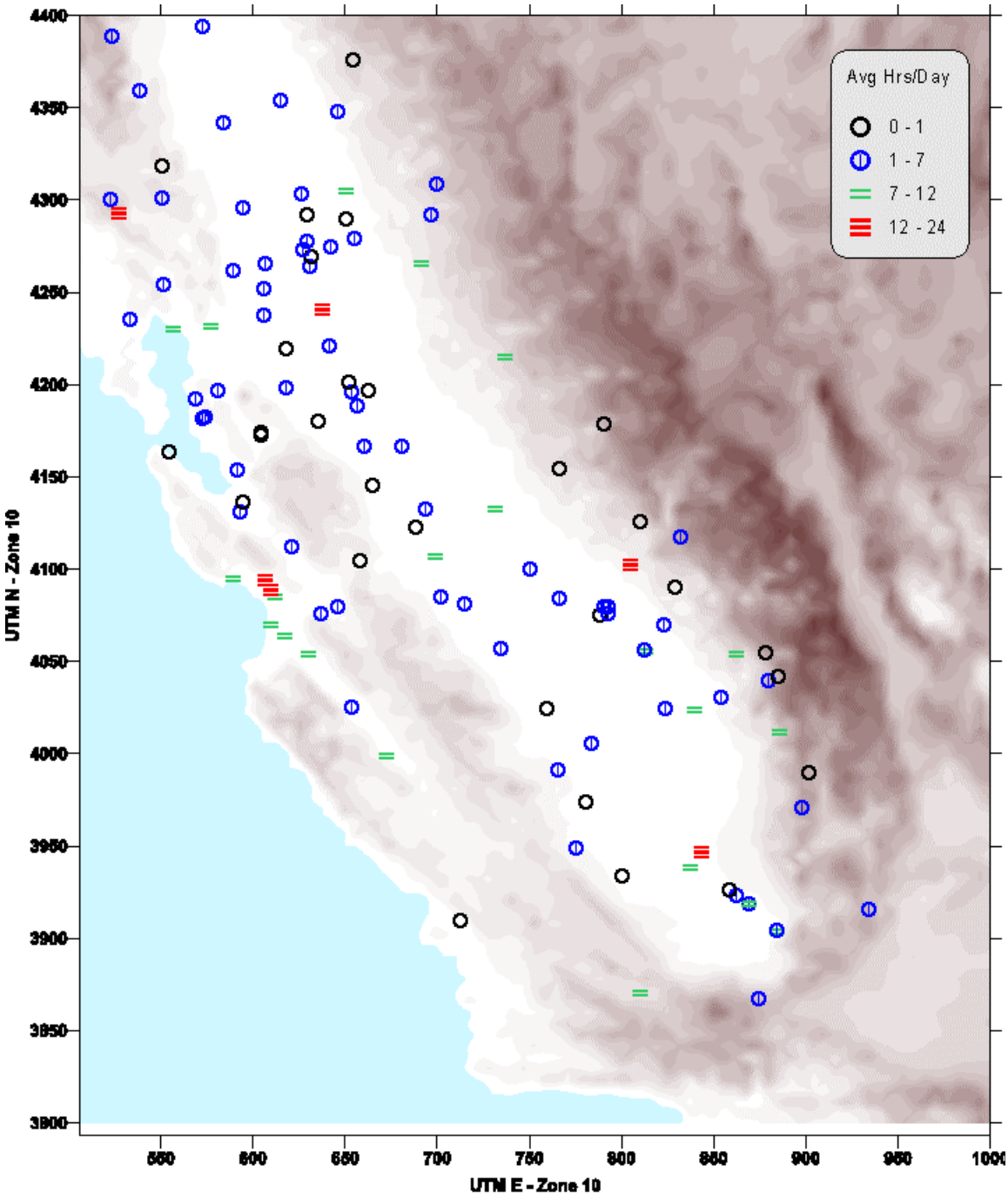
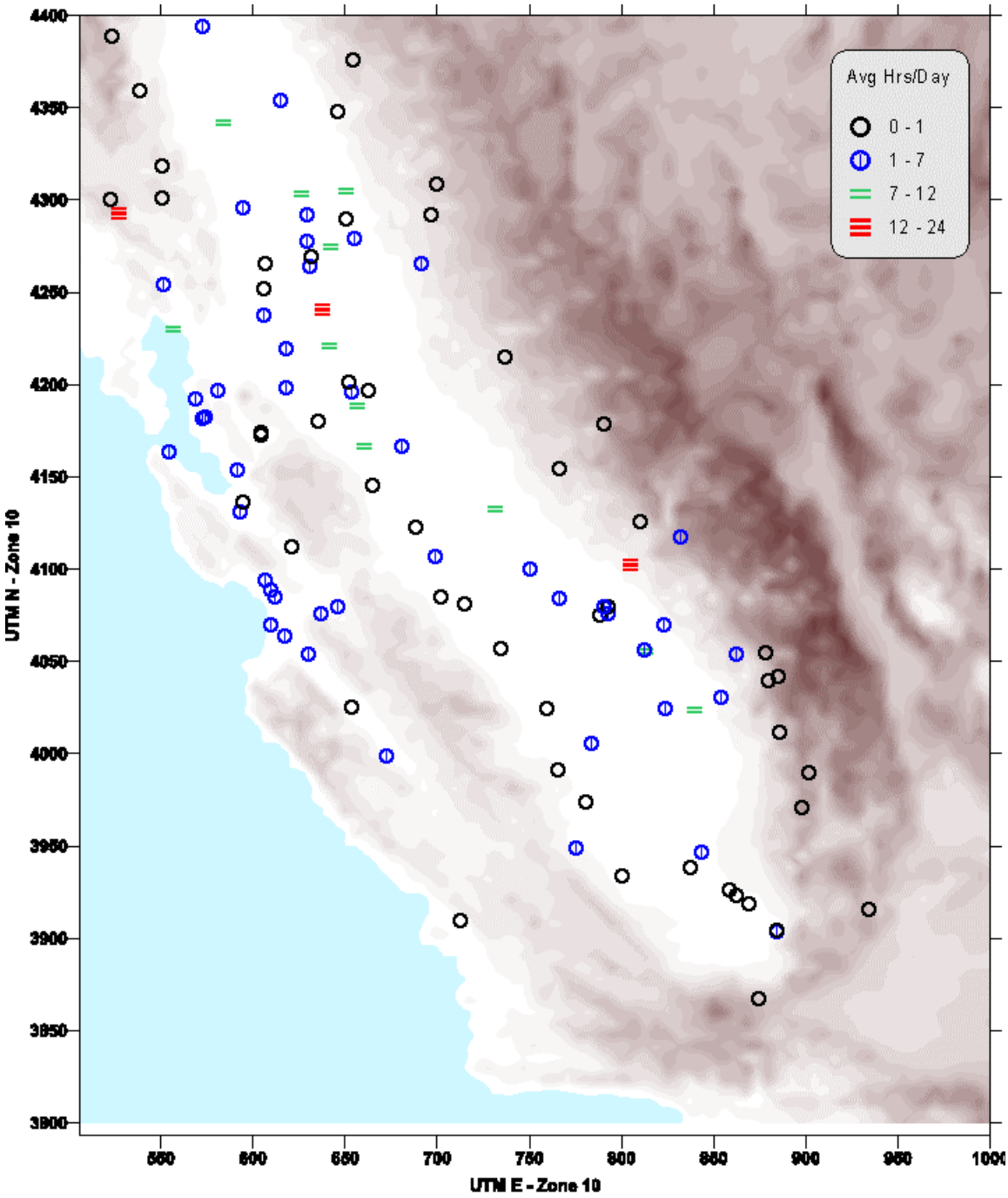

Avg Hrs/Day
0 - 1
1 - 7
7 - 12
12 - 24
UTM N - Zone 10
UTM E - Zone 10
4400
4350
4300
4250
4200
4150
4100
4050
4000
3950
3900
3850
3800
550
600
650
700
750
800
850
900
950
1000
Average Number of Hours Rh > 95 Percent for EP1 (12/1/99 to 12/8/99)

Figure 23



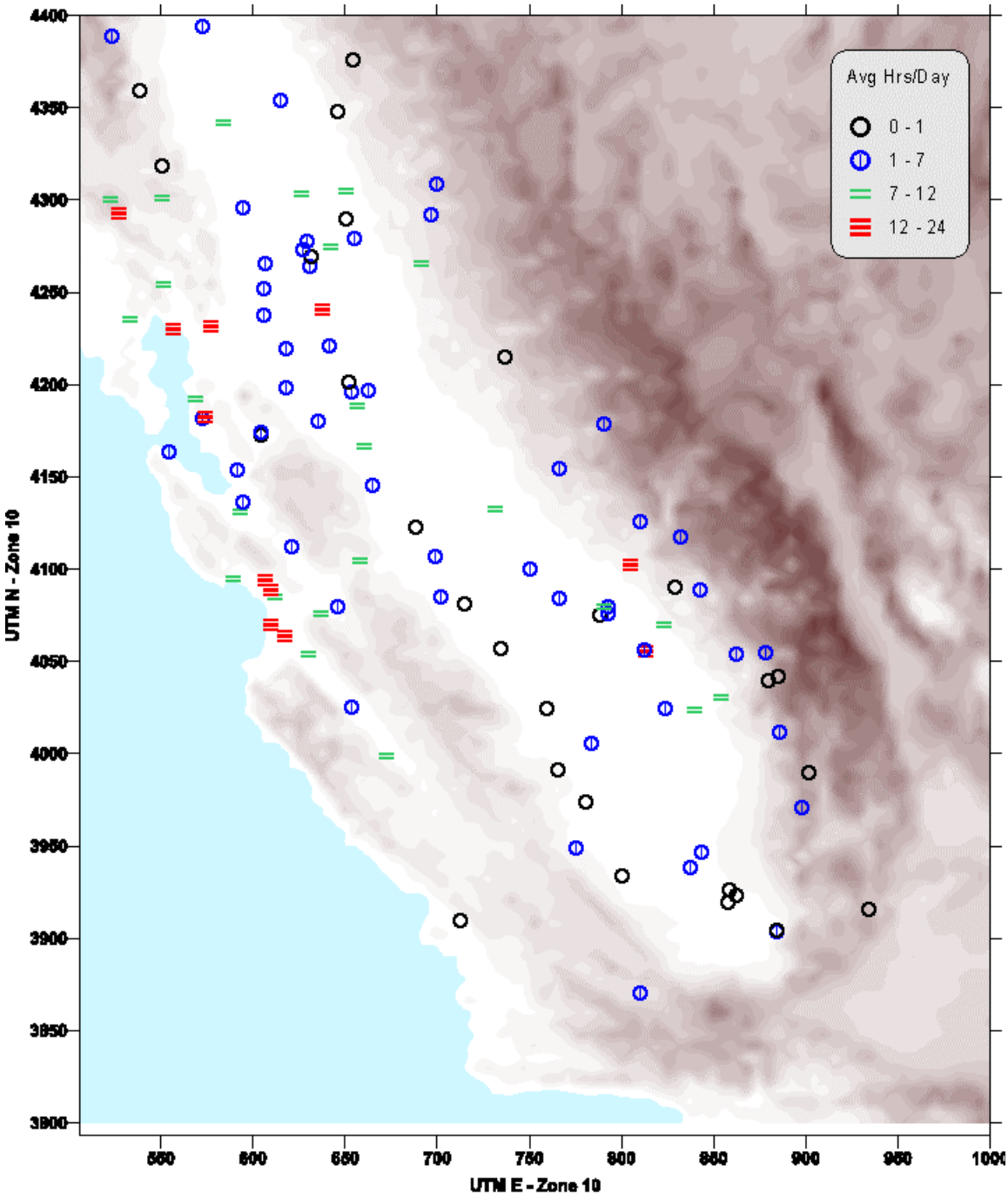
Average Number of Hours Rh > 95 Percent for EP2 (12/10/99 to 12/13/99)

Figure 24



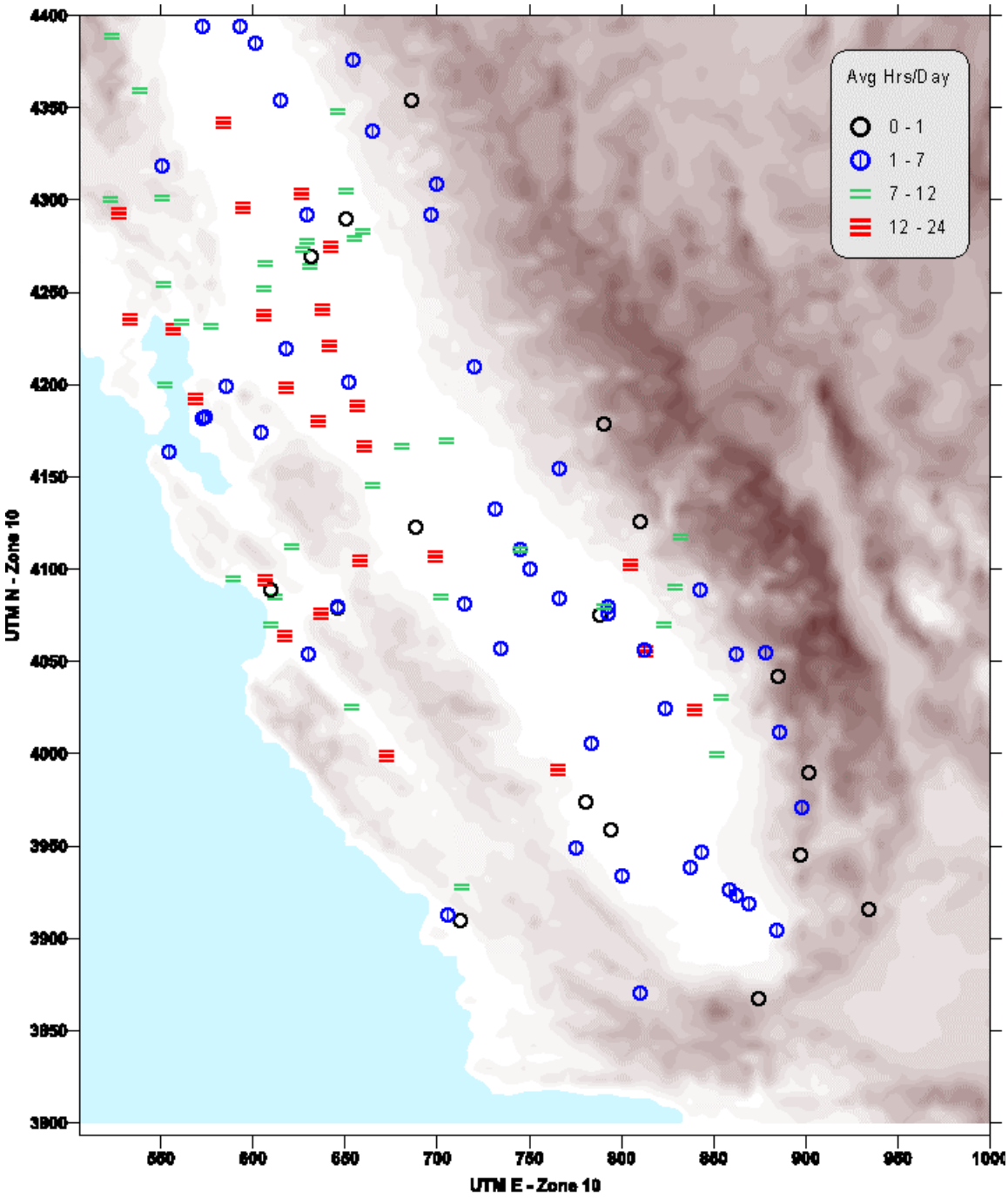
Average Number of Hours Rh > 95 Percent for EP3 (12/14/99 to 1/2/00)

Figure 25



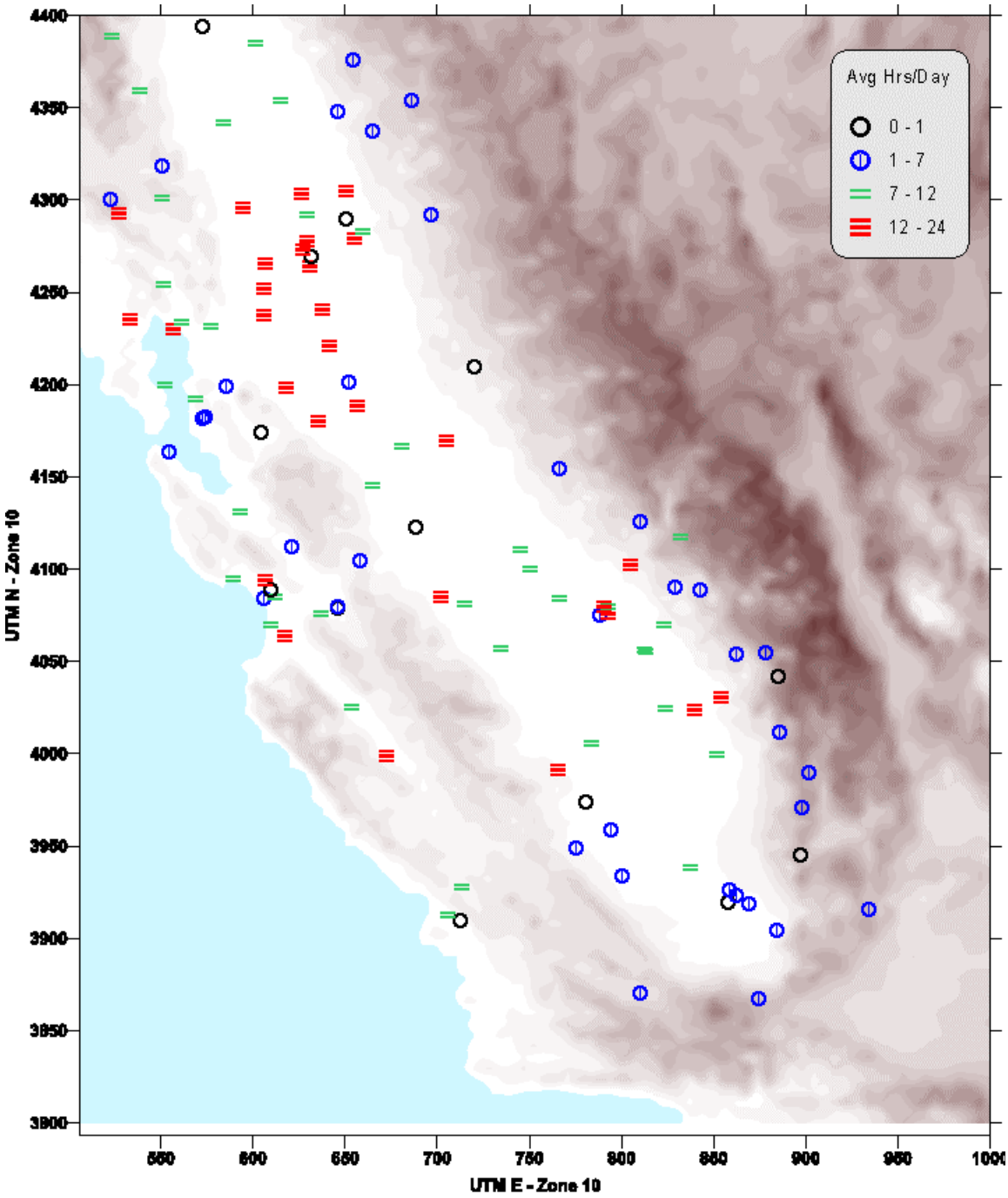
Average Number of Hours Rh > 95 Percent for EP4 (1/2/00 to 1/12/00)

Figure 26



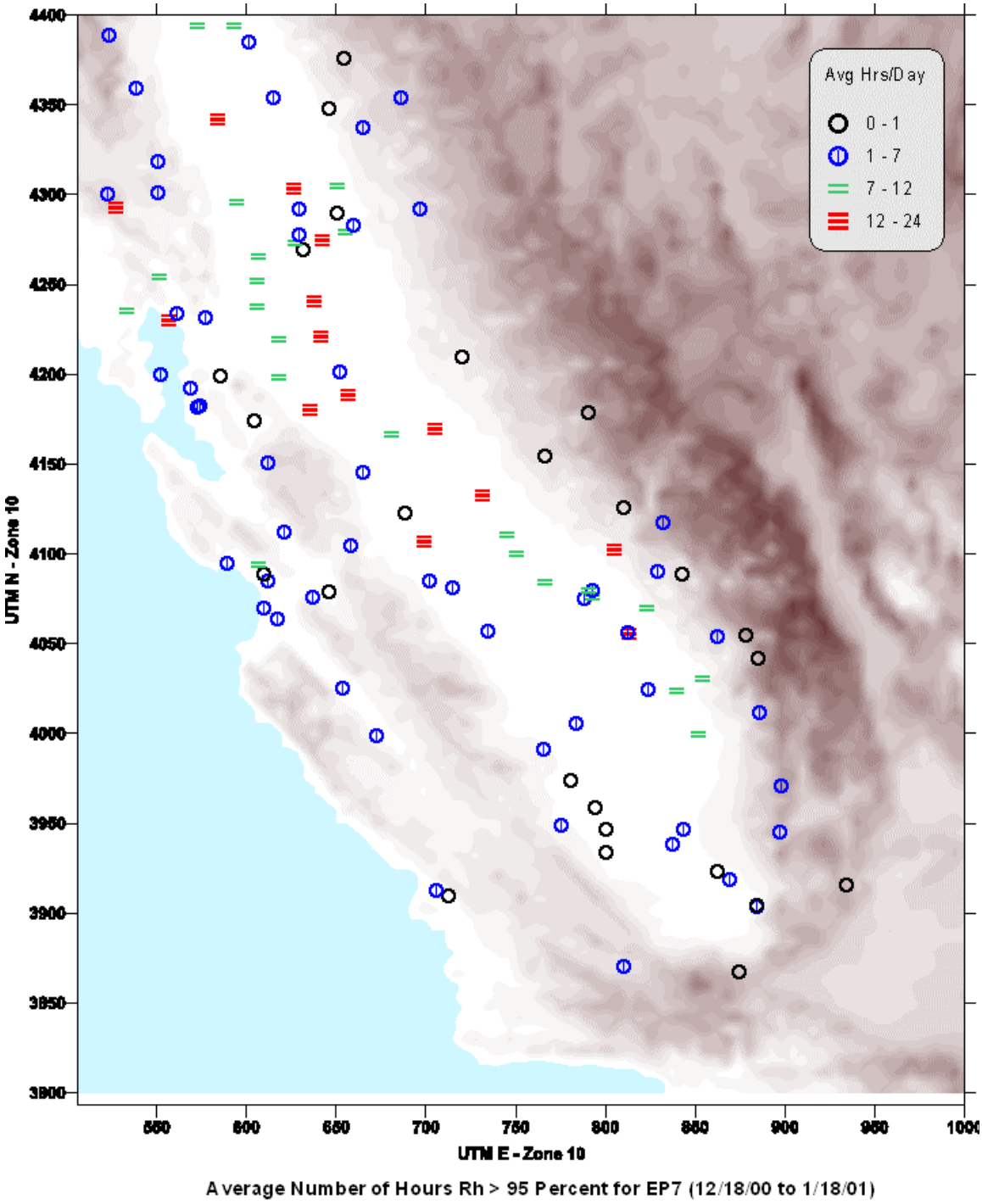
Average Number of Hours Rh > 95 Percent for EP5 (11/15/00 to 11/29/00)

Figure 27



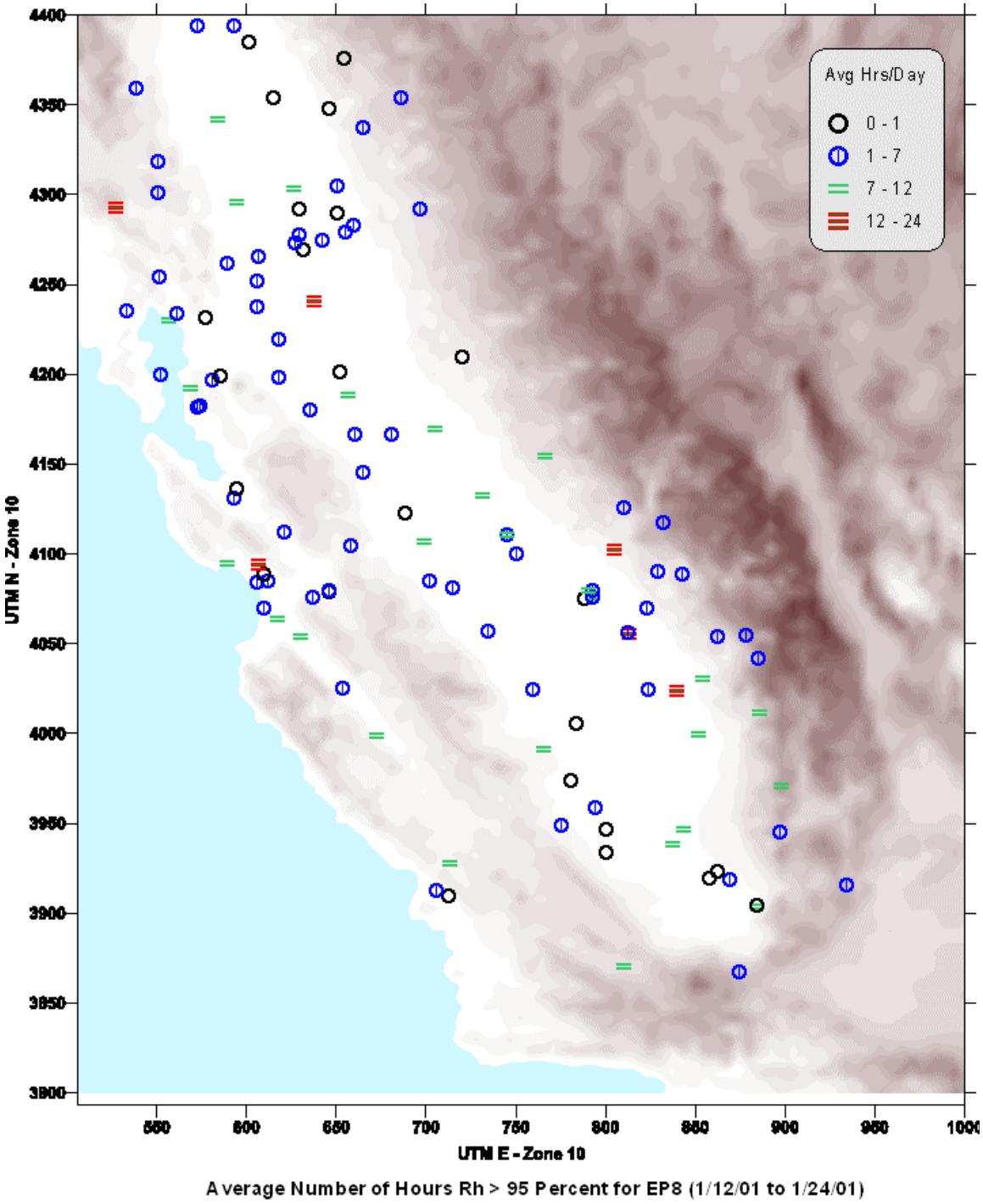
Average Number of Hours Rh > 95 Percent for EP6 (11/30/00 to 12/13/00)

Figure 28



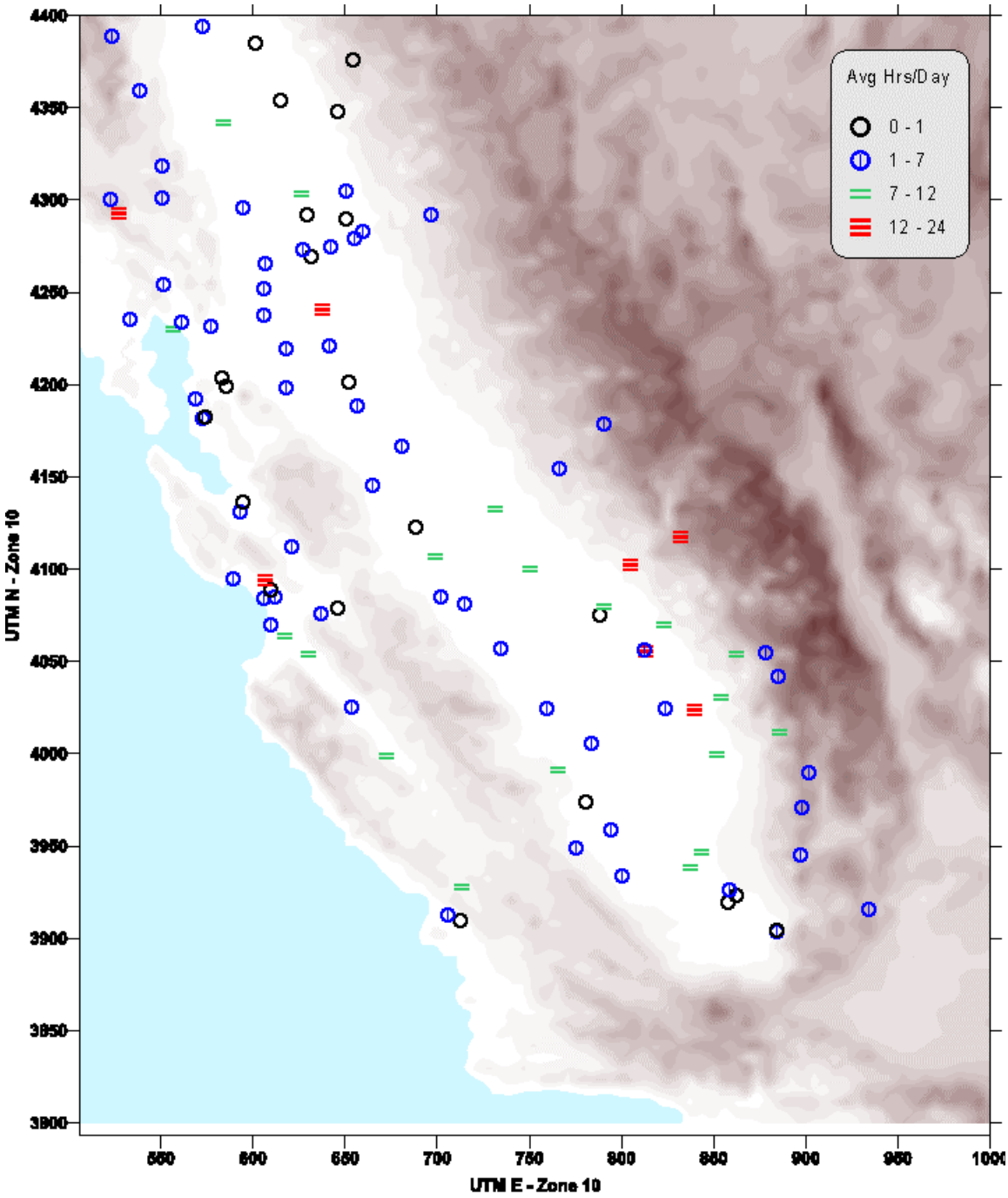
Average Number of Hours Rh > 95 Percent for EP7 (12/18/00 to 1/18/01)

Figure 29



Average Number of Hours Rh > 95 Percent for EP8 (1/12/01 to 1/24/01)

Figure 30



Average Number of Hours Rh > 95 Percent for EP9 (1/26/01 to 2/7/01)

Figure 31

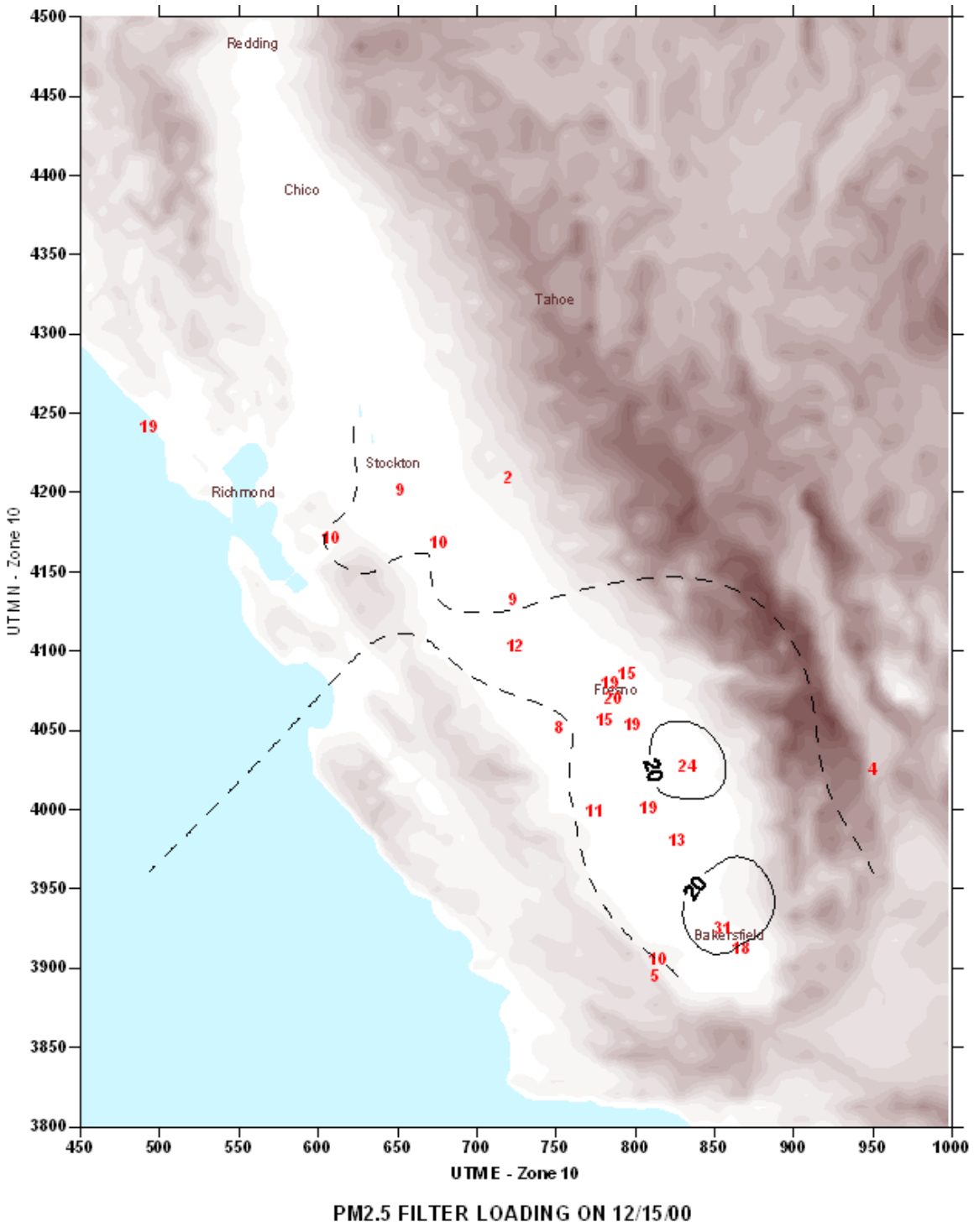

Redding
Chico
Tahoe
Stockton
Richmond
Fresno
Bakersfield
UTMN - Zone 10
UTME - Zone 10
4500
4450
4400
4350
4300
4250
4200
4150
4100
4050
4000
3950
3900
3850
3800
450
500
550
600
650
700
750
800
850
900
950
1000
19
9
2
10
10
9
12
15
19
20
15
8
19
20
24
4
11
19
13
20
31
18
10
5
PM2.5 FILTER LOADING ON 12/15/00

Figure 32

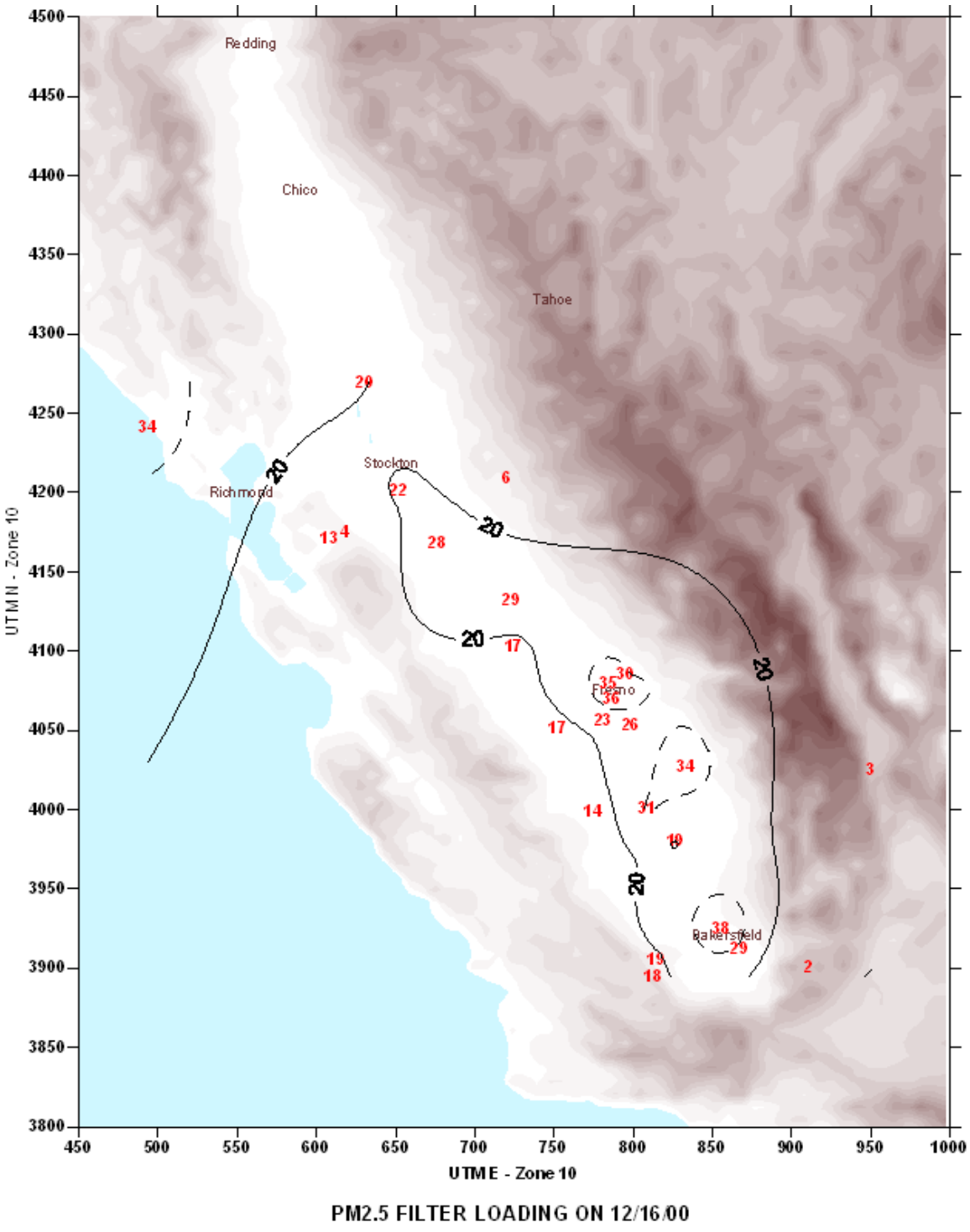

Redding
Chico
Tahoe
Stockton
Richmond
Fresno
Bakersfield
UTMN - Zone 10
UTME - Zone 10
PM2.5 FILTER LOADING ON 12/16/00

Figure 33

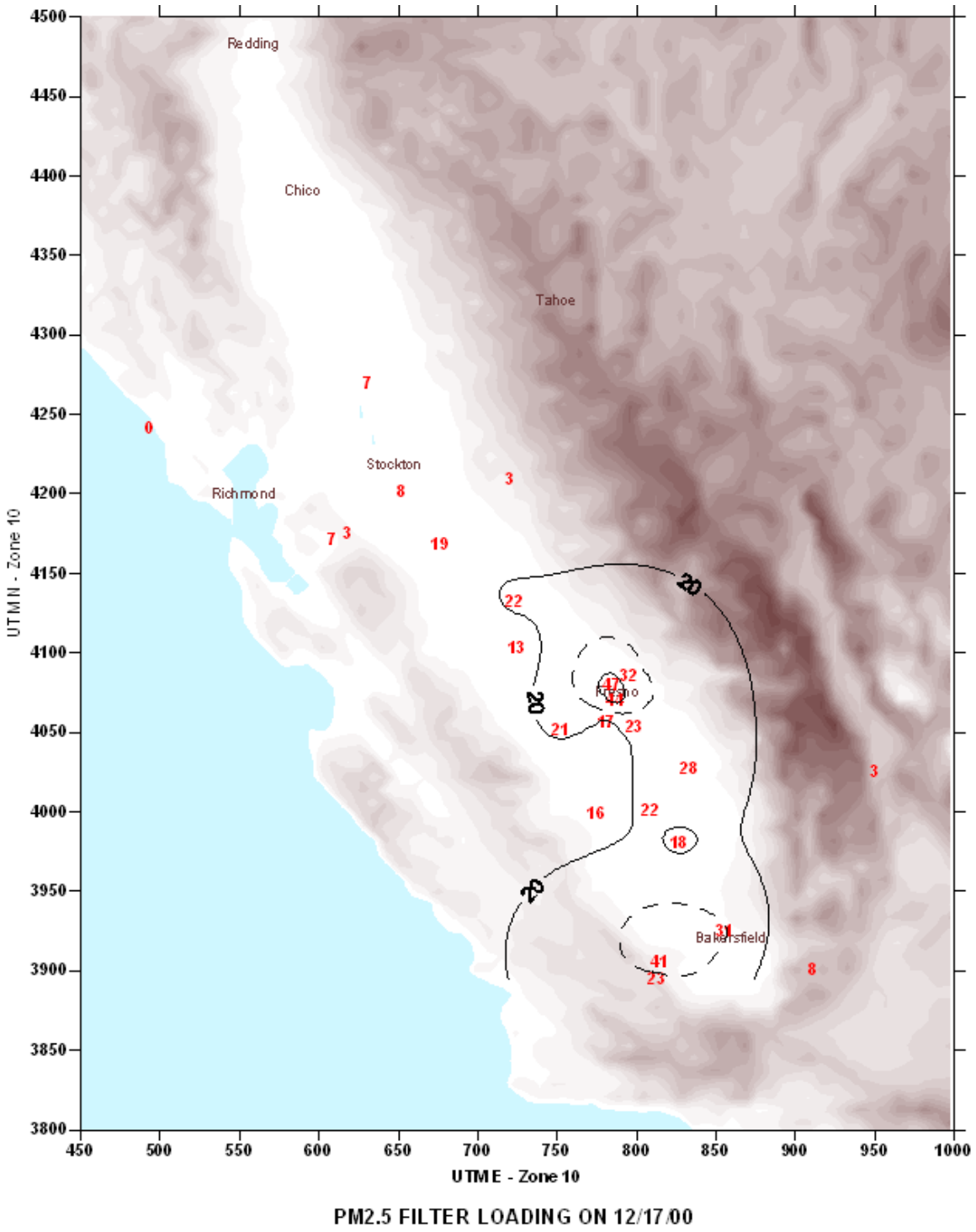

Redding
Chico
Tahoe
Stockton
Richmond
Bakersfield
UTM N - Zone 10
UTM E - Zone 10
PM2.5 FILTER LOADING ON 12/17/00

Figure 34

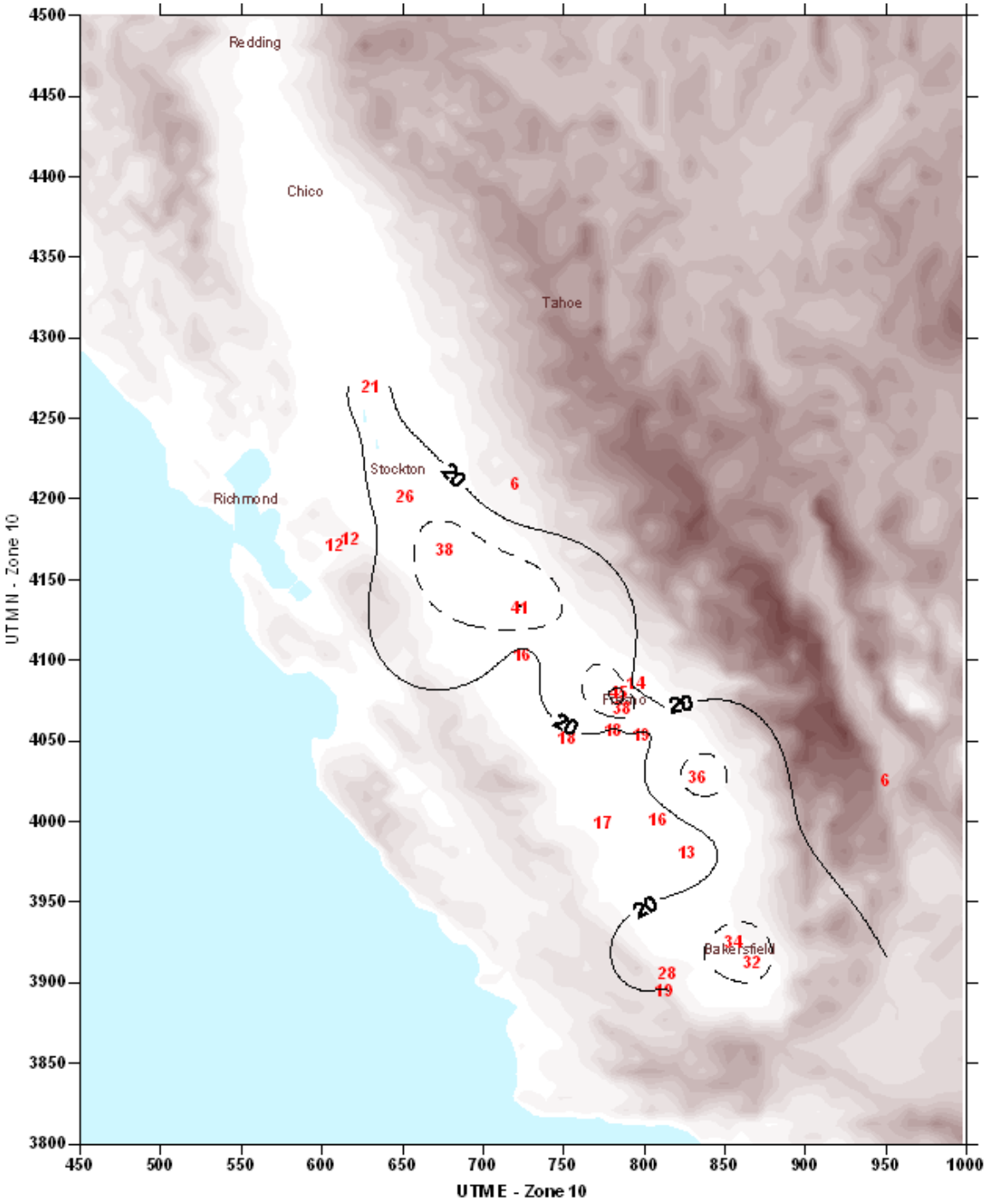

Redding
Chico
Tahoe
Stockton
Richmond
Fresno
Bakersfield
UTM N - Zone 10
UTM E - Zone 10
4500
4450
4400
4350
4300
4250
4200
4150
4100
4050
4000
3950
3900
3850
3800
450
500
550
600
650
700
750
800
850
900
950
1000
PM2.5 FILTER LOADING ON 12/18/00

Figure 35

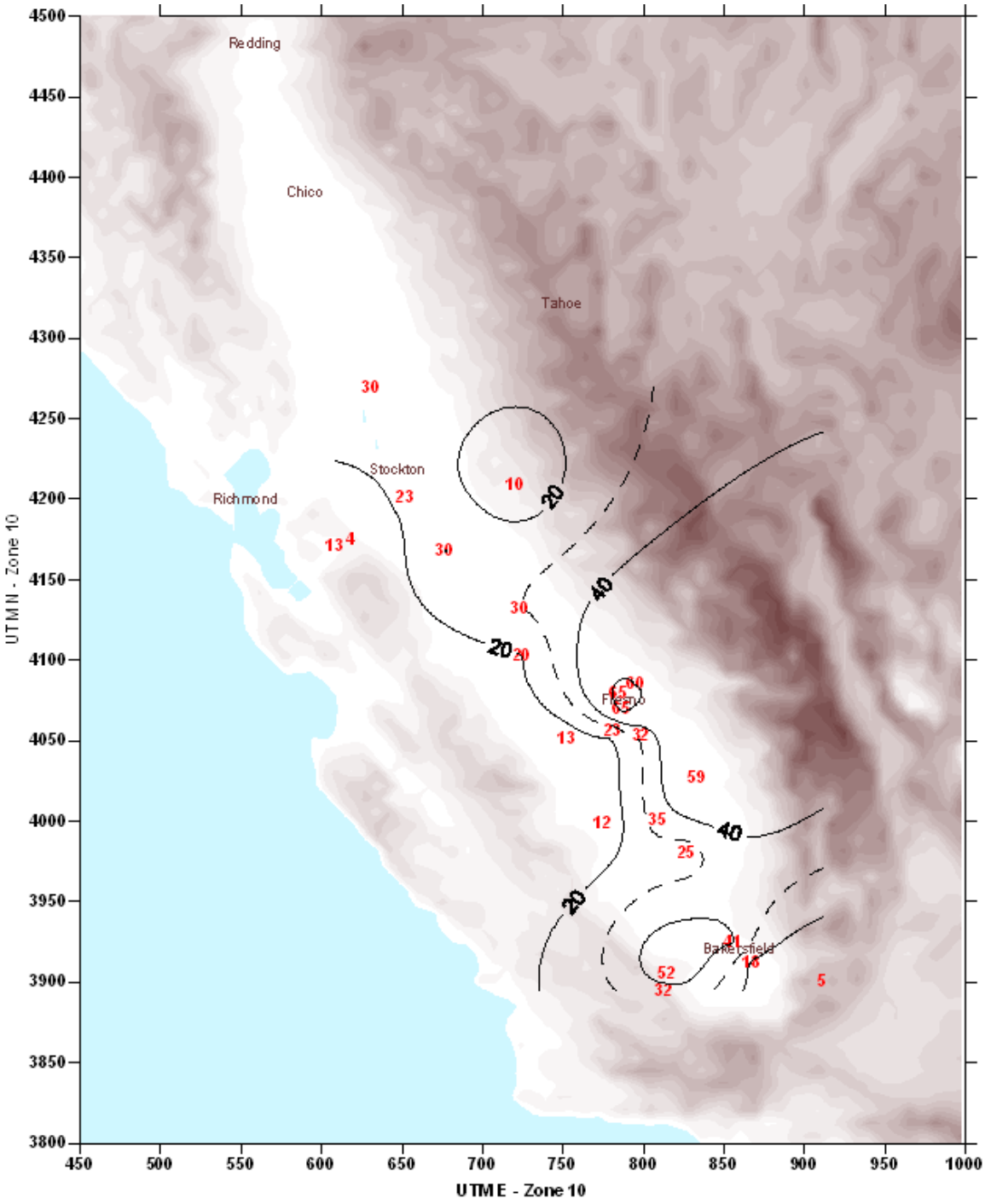

Redding
Chico
Tahoe
Stockton
Richmond
Fresno
Bakersfield
UTMN - Zone 10
UTME - Zone 10
PM2.5 FILTER LOADING ON 12/25/00

Figure 36

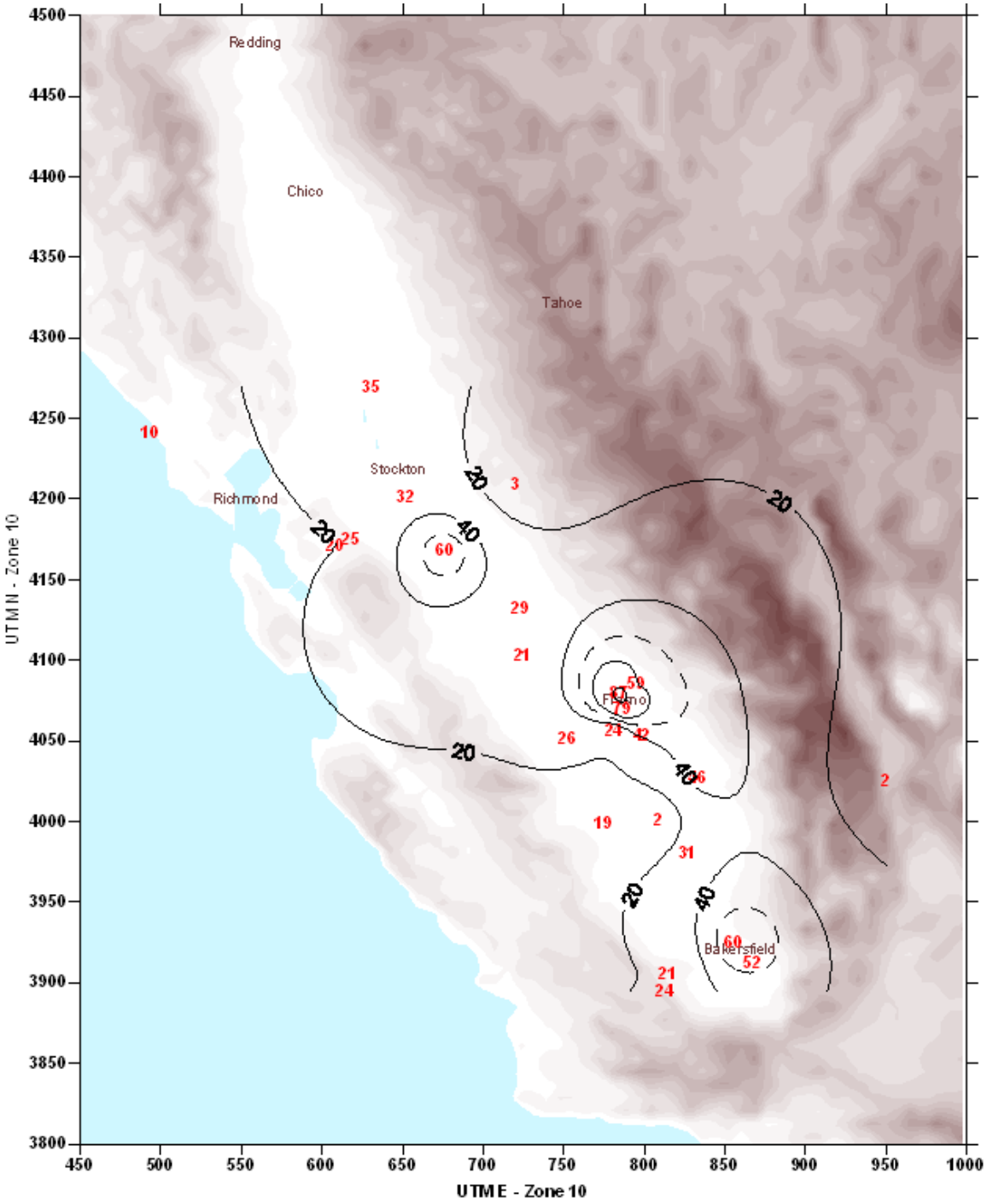

Redding
Chico
Tahoe
Stockton
Richmond
Fresno
Bakersfield
UTM N - Zone 10
UTM E - Zone 10
PM2.5 FILTER LOADING ON 12/26/00

Figure 37

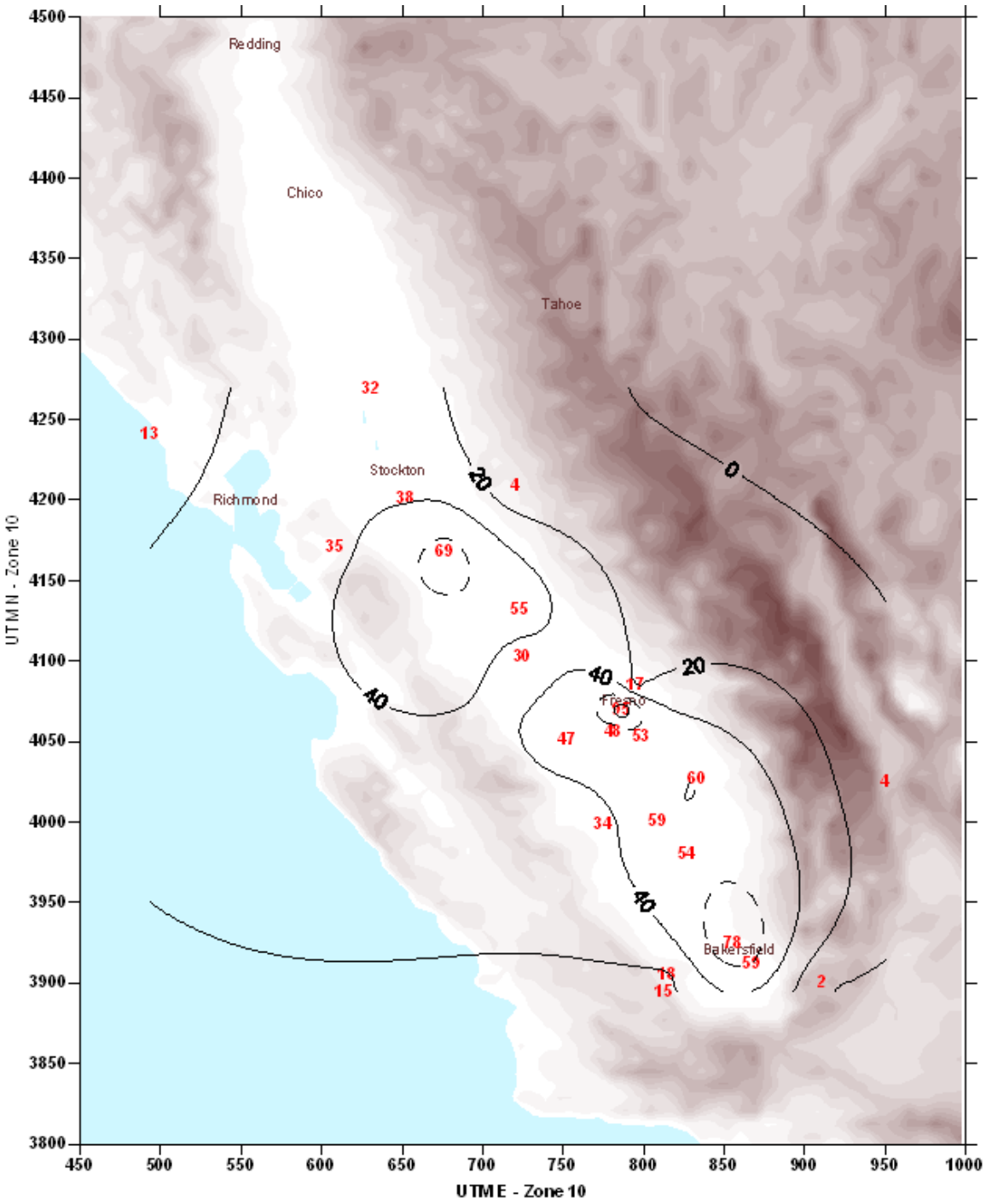

Redding
Chico
Tahoe
Stockton
Richmond
Fresno
Bakersfield
UTM N - Zone 10
UTM E - Zone 10
PM2.5 FILTER LOADING ON 12/27/00

Figure 38

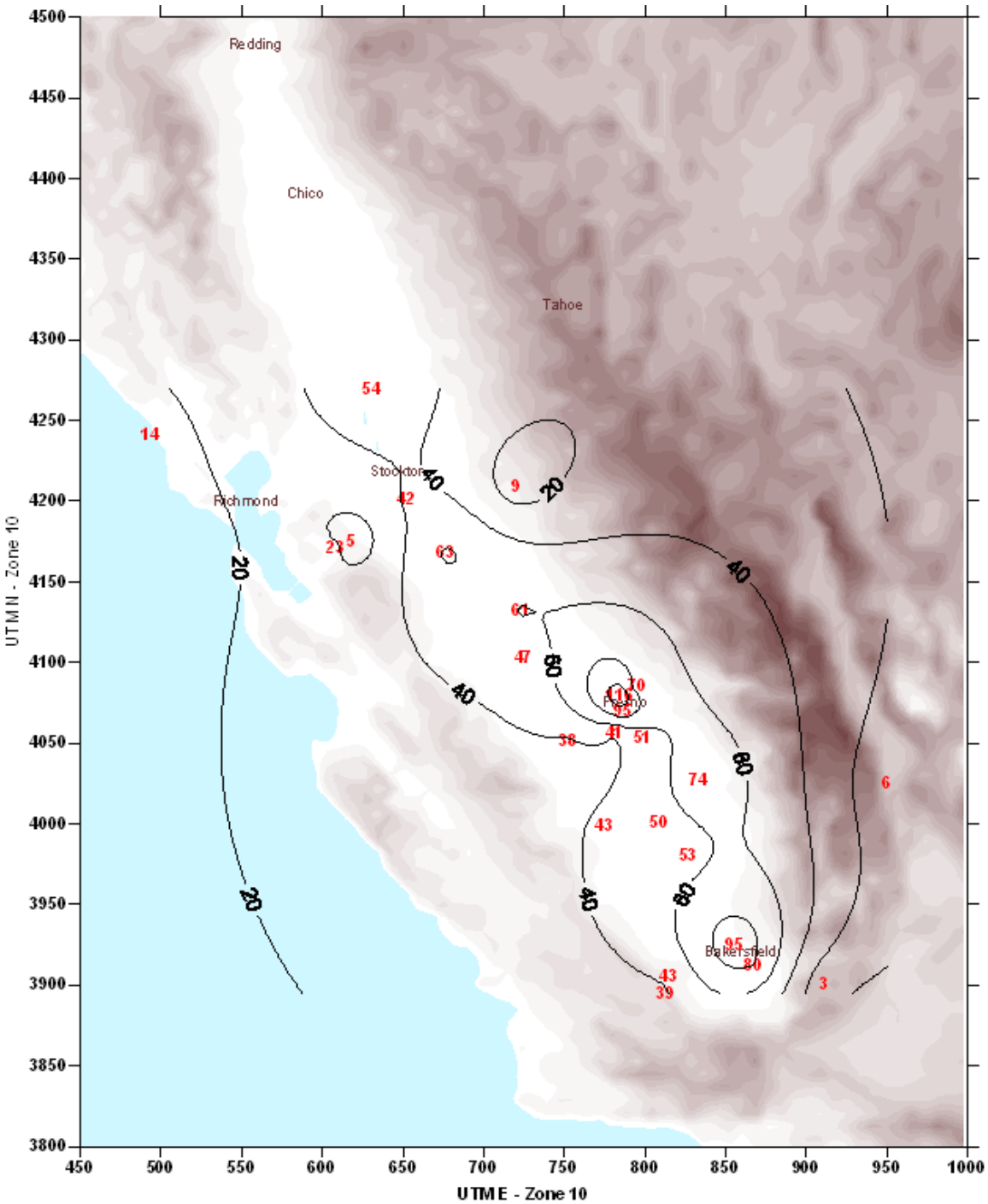
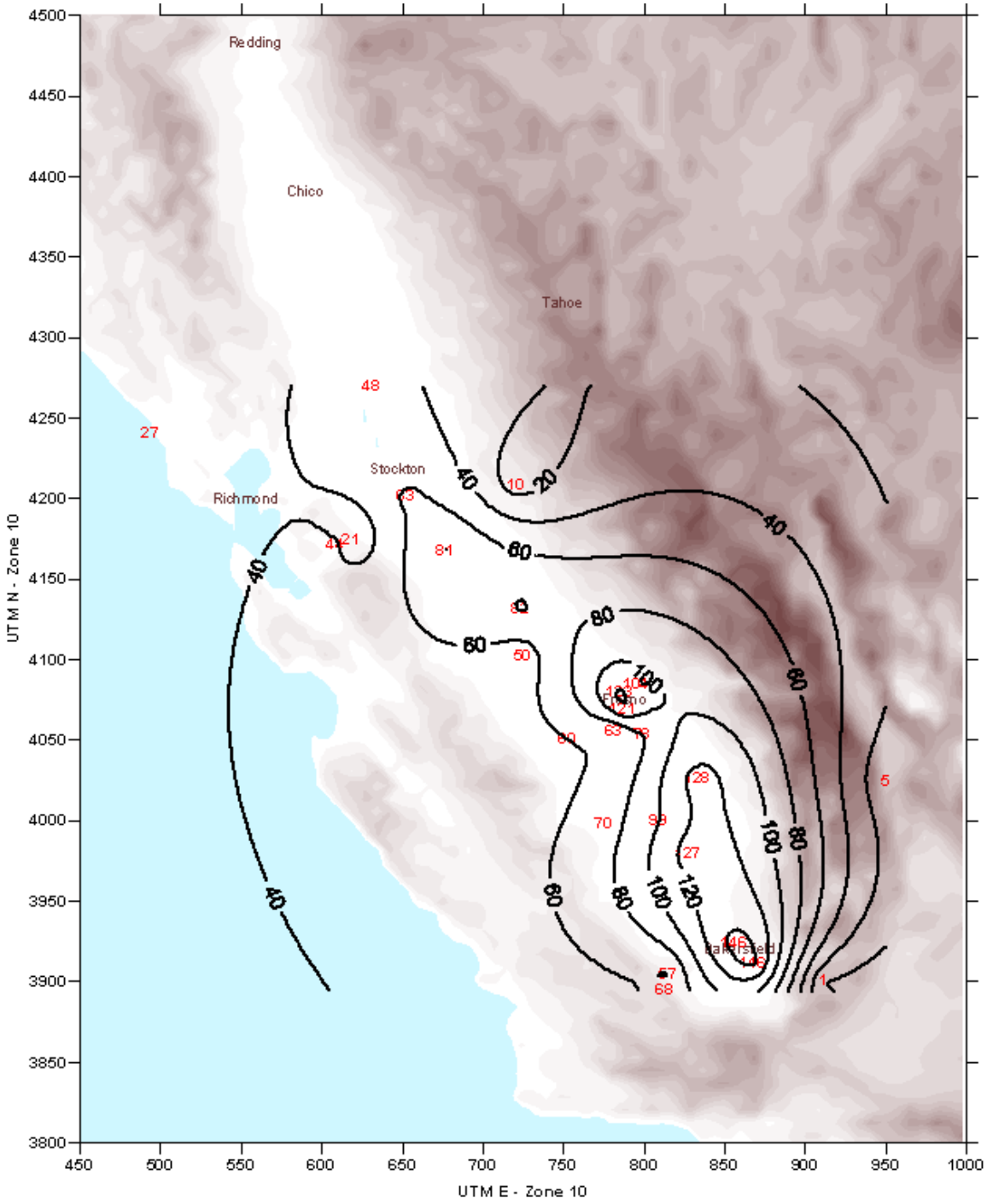

Redding
Chico
Tahoe
Stockton
Richmond
Fresno
Bakersfield
UTM N - Zone 10
UTM E - Zone 10
PM2.5 FILTER LOADING ON 12/28/00

Figure 39



PM2.5 FILTER LOADING ON 1/4/01

Figure 40

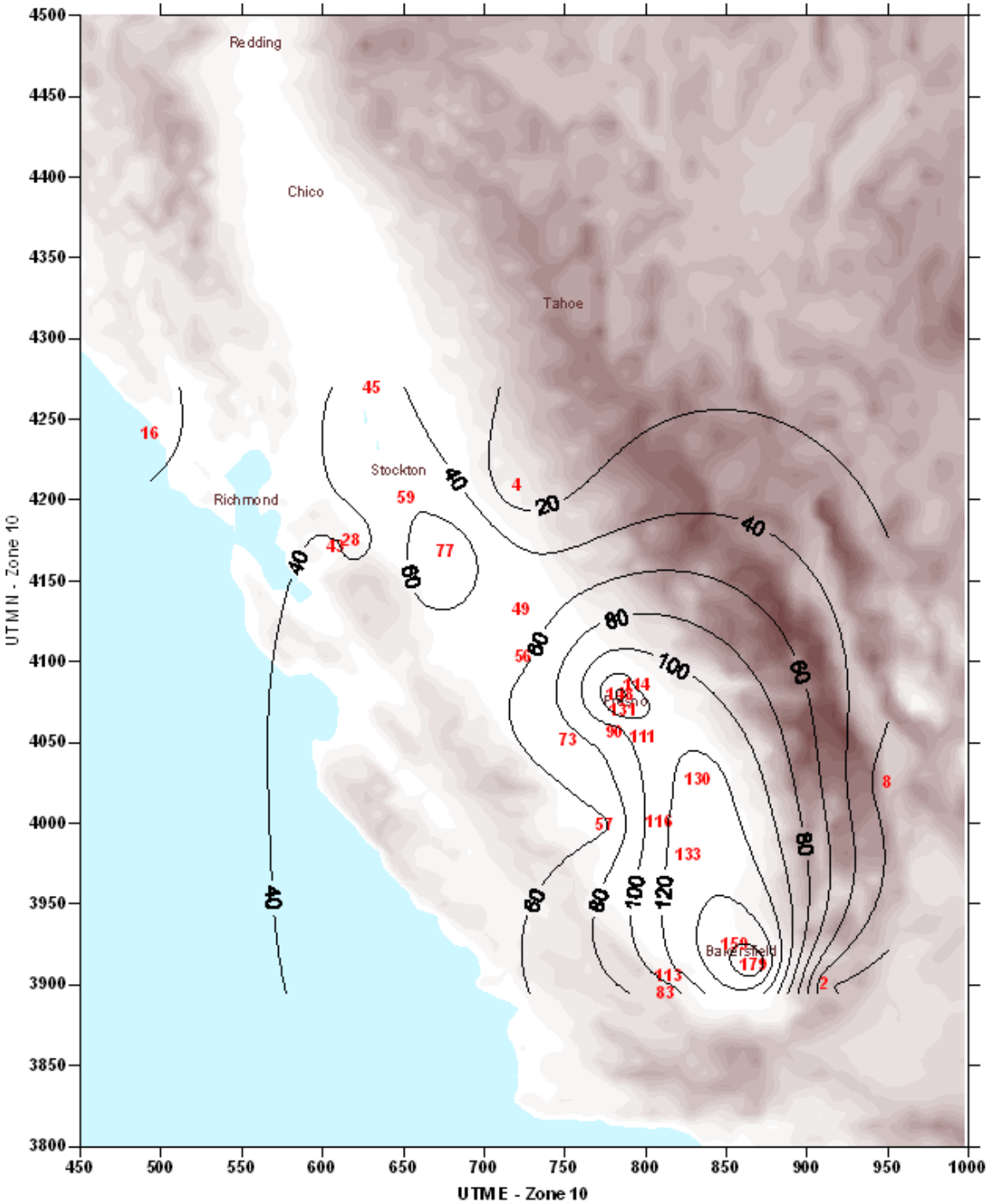

Redding
Chico
Tahoe
Stockton
Richmond
Bakersfield
UTMN - Zone 10
UTME - Zone 10
PM2.5 FILTER LOADING ON 1/5/01

Figure 41

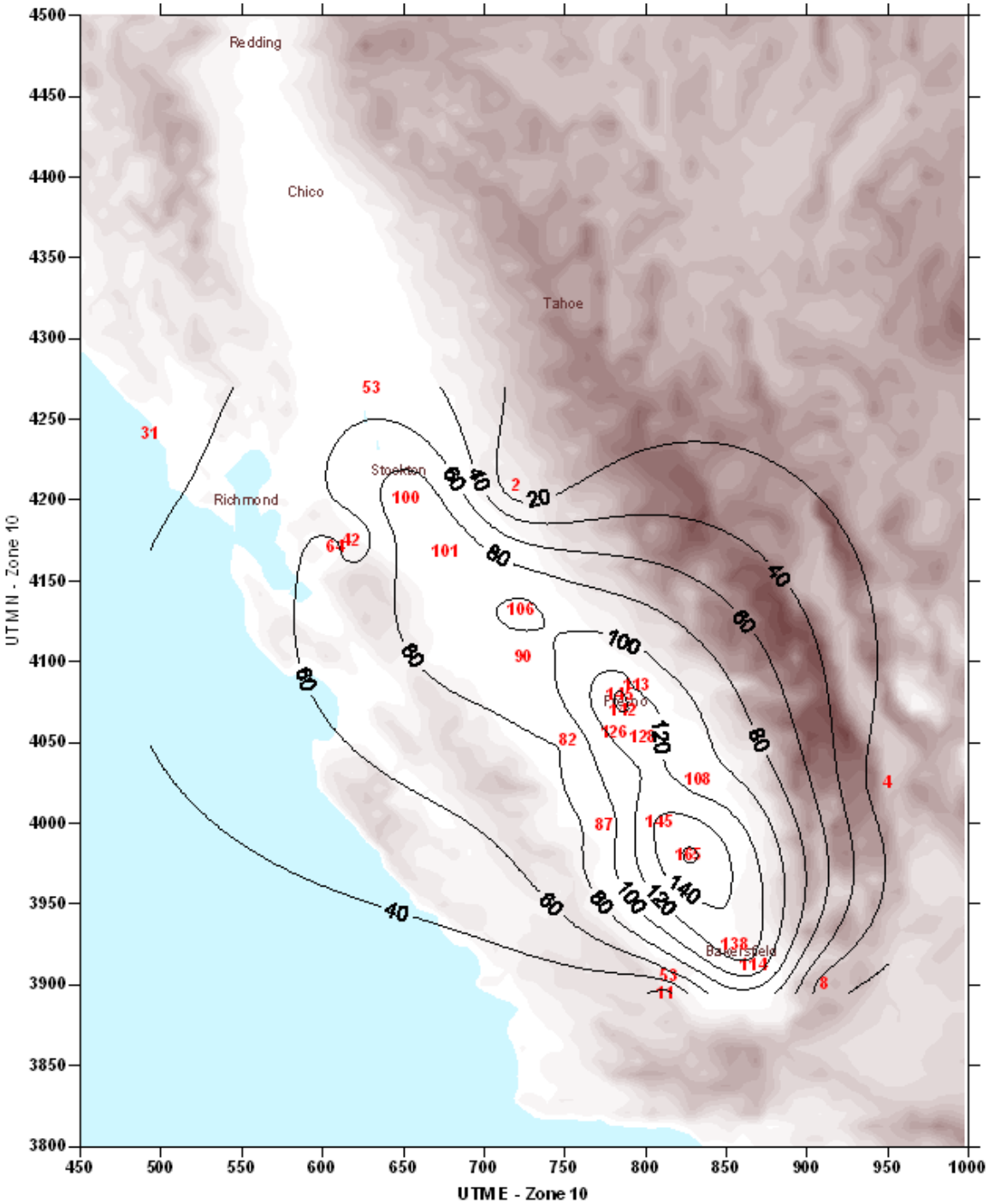

Redding
Chico
Tahoe
Stockton
Richmond
Bakersfield
UTM N - Zone 10
UTM E - Zone 10
PM2.5 FILTER LOADING ON 1/6/01

Figure 42

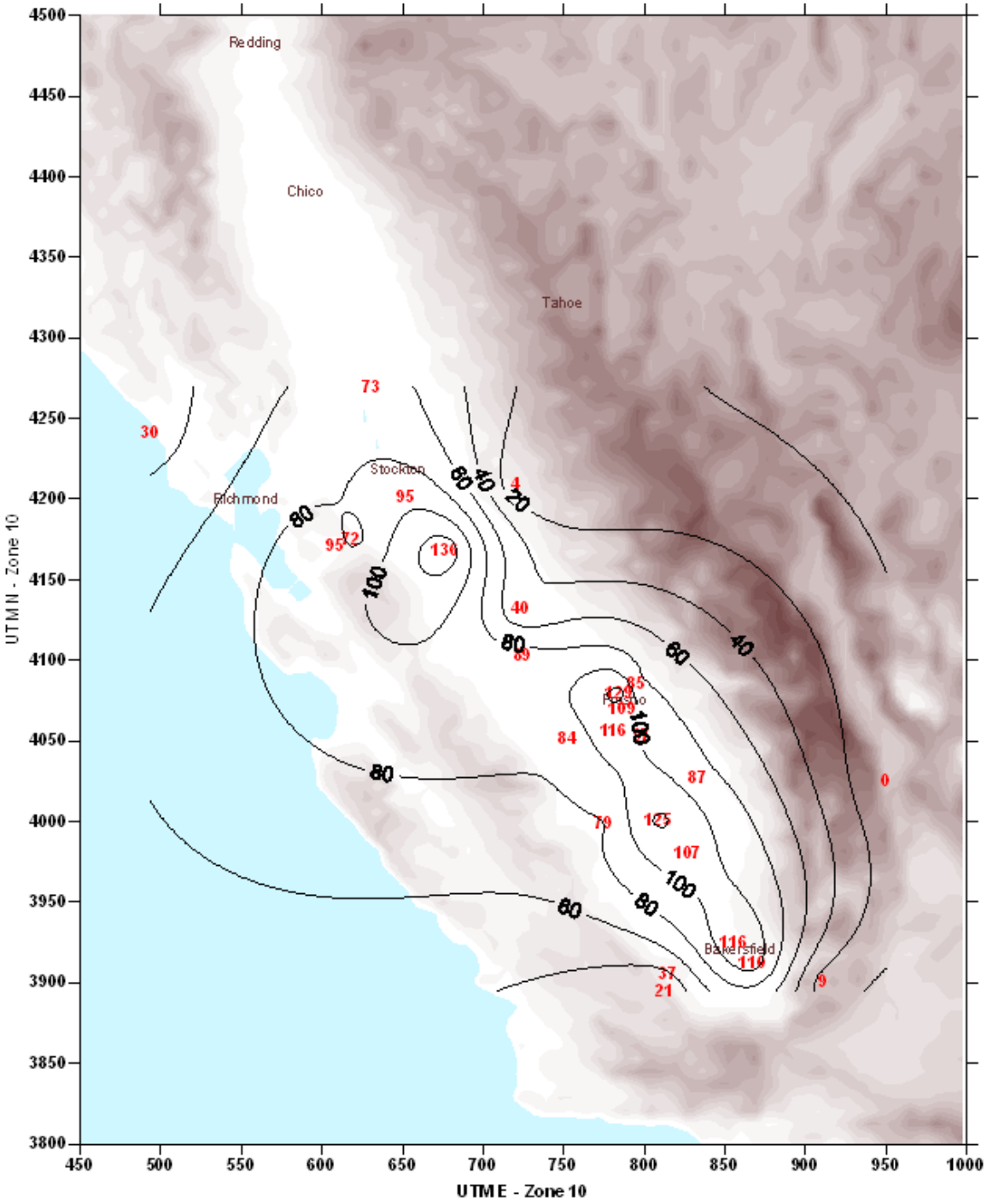

Redding
Chico
Tahoe
Stockton
Richmond
Fresno
Bakersfield
UTM N - Zone 10
UTME - Zone 10
4500
4450
4400
4350
4300
4250
4200
4150
4100
4050
4000
3950
3900
3850
3800
450
500
550
600
650
700
750
800
850
900
950
1000
PM2.5 FILTER LOADING ON 1/7/01

Figure 43

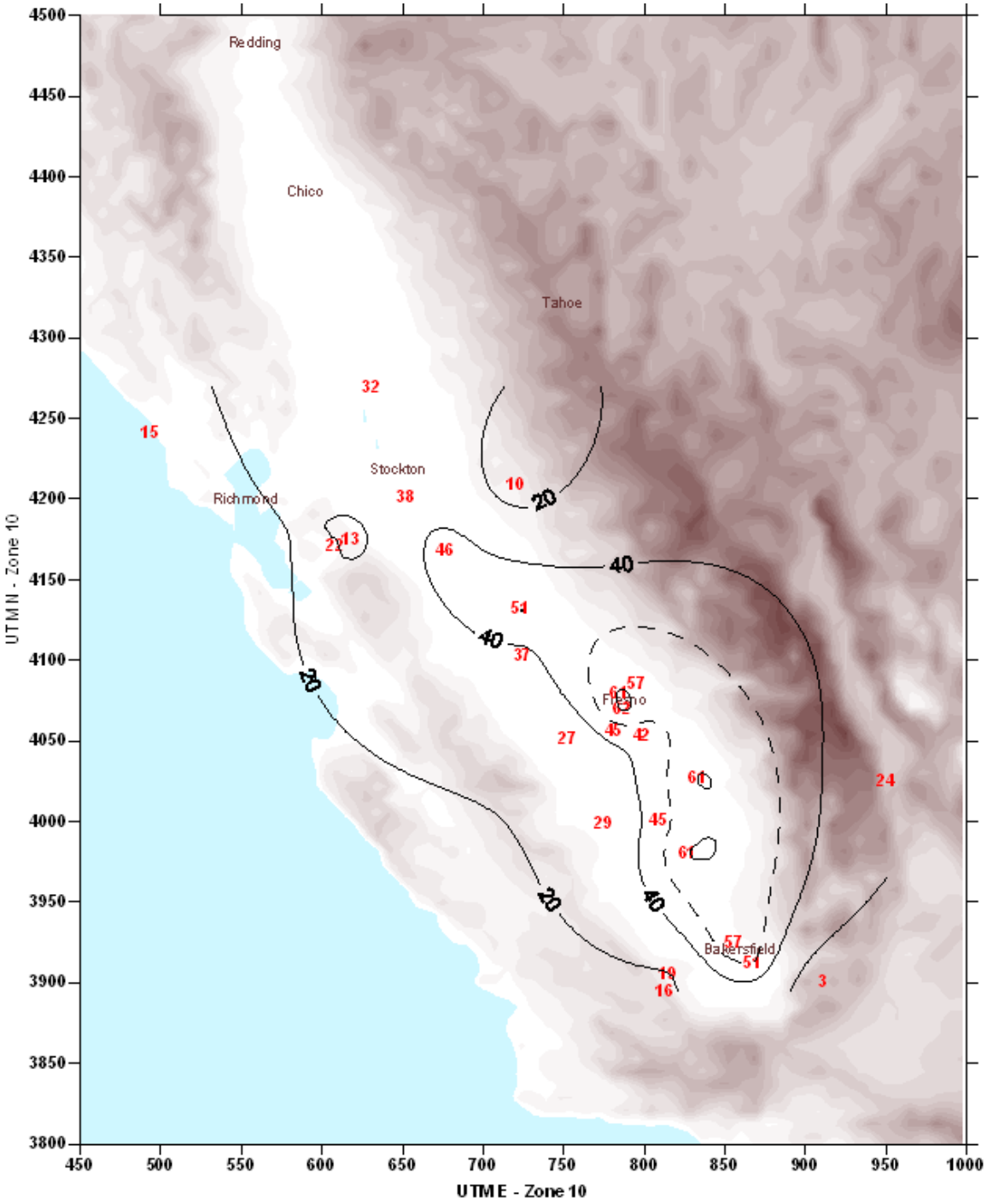

Redding
Chico
Tahoe
Stockton
Richmond
Fresno
Bakersfield
UTM N - Zone 10
UTM E - Zone 10
PM2.5 FILTER LOADING ON 2/1/01

Figure 44

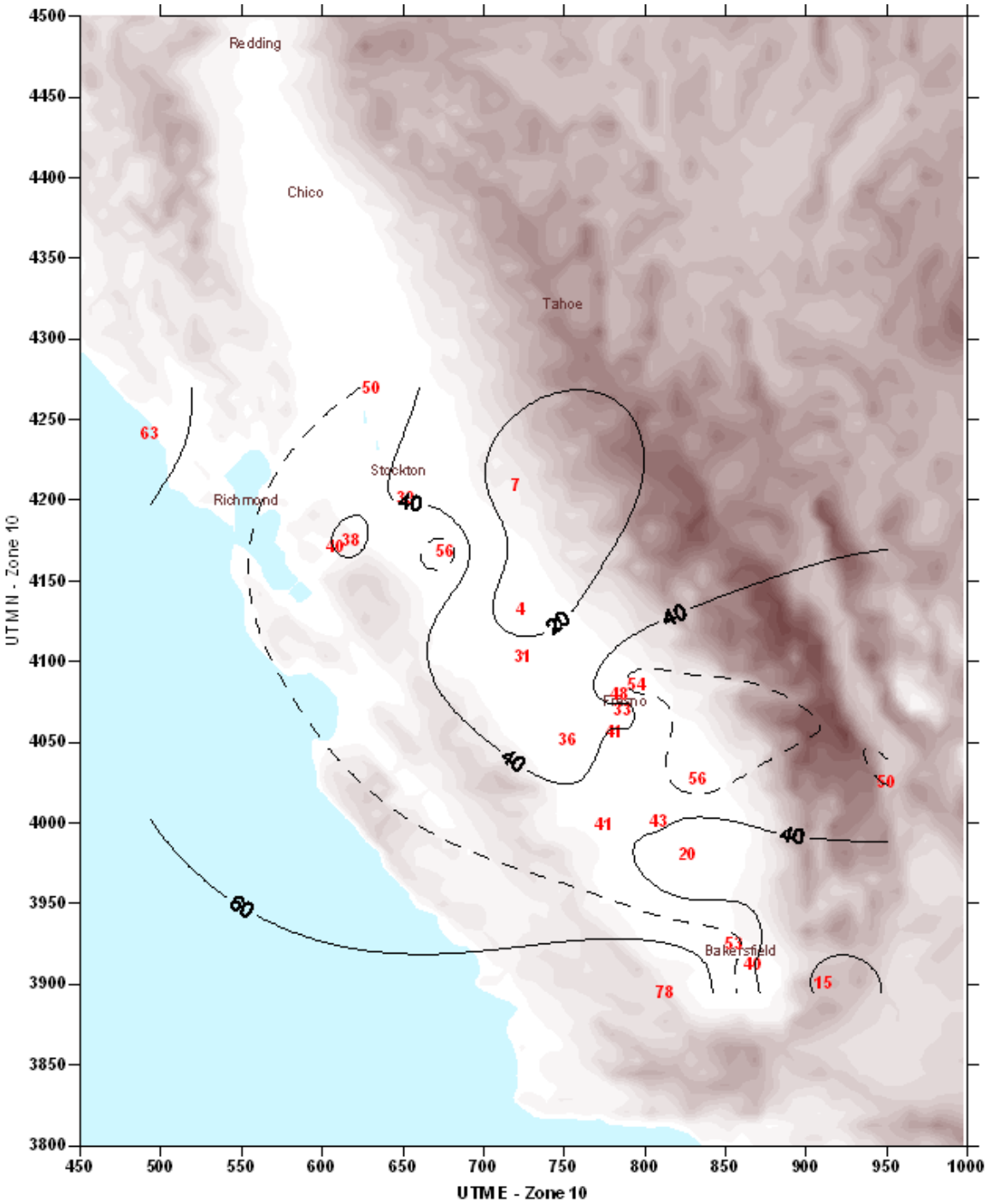

Redding
Chico
Tahoe
Stockton
Richmond
Bakersfield
Fresno
UTM N - Zone 10
UTM E - Zone 10
4500
4450
4400
4350
4300
4250
4200
4150
4100
4050
4000
3950
3900
3850
3800
450
500
550
600
650
700
750
800
850
900
950
1000
63
50
40
38
56
7
4
20
40
31
54
48
53
41
36
40
56
50
41
43
40
20
60
53
40
78
15
PM2.5 FILTER LOADING ON 2/2/01

Figure 45

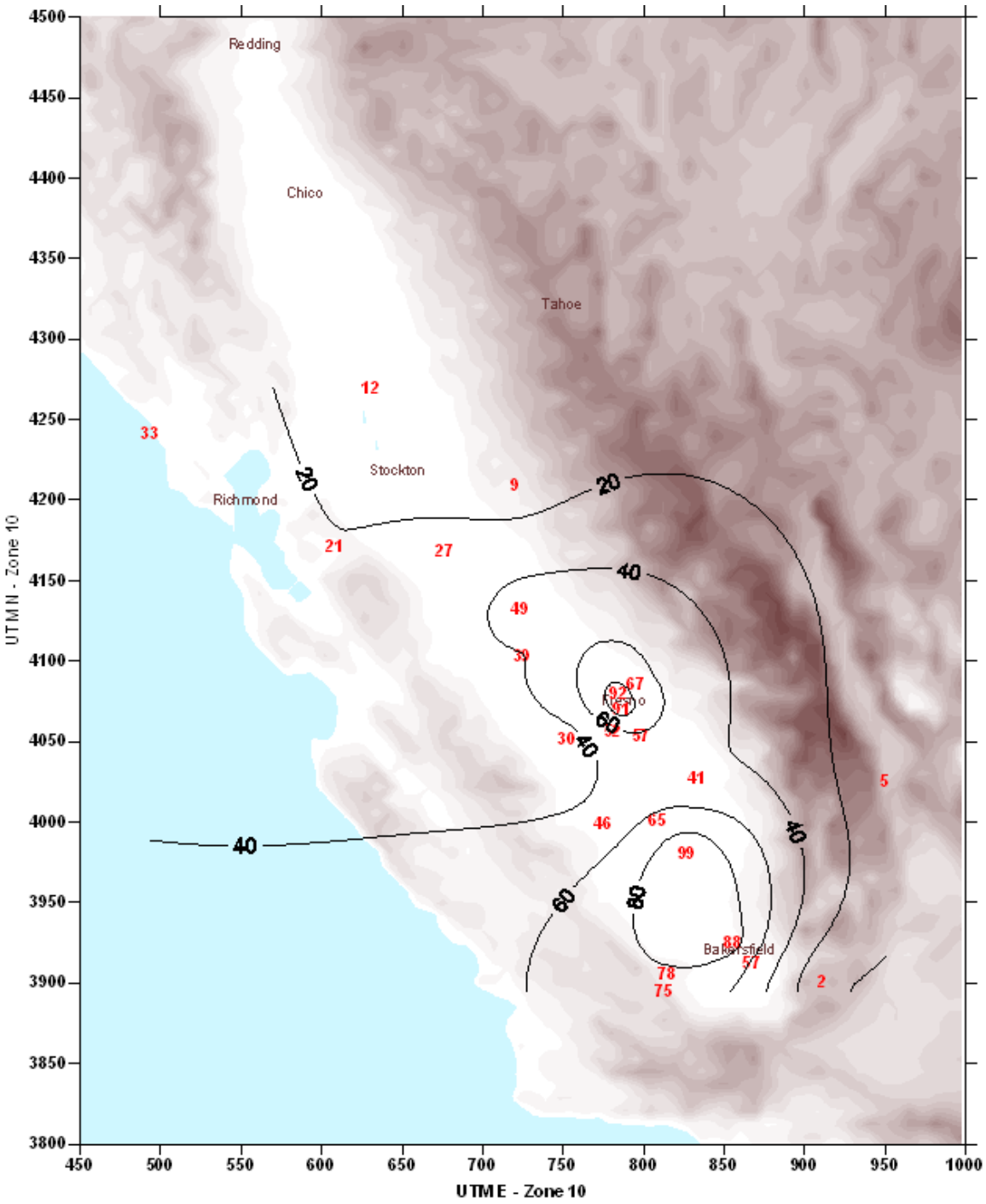

Redding
Chico
Tahoe
Stockton
Richmond
Bakersfield
UTMN - Zone 10
UTME - Zone 10
PM2.5 FILTER LOADING ON 2/3/01

Figure 46